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FINAL REPORT FOR RESEARCH AGREEMENT

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"Landscape Ecology of Lumber Pine on the
Rocky Mountain Front, Montana: Biotic,
Abiotic and Disturbance Interaction"

UNIVERSITY OF MONTANA

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LIMBER PINE ECOLOGY OF THE ROCKY MOUNTAIN FRONT, MONTANA

Prepared for:

Intermountain Fire Lab

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This report and information herein is considered preliminary research and in no way should be interpreted as final analysis or presentation. The final report of this information will appear as a series of manuscripts and a dissertation and will be available late 2001.

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Introduction:

Limber pine (*Pinus flexilis*) is a widespread coniferous tree distributed throughout the western United States, primarily in upper timberline habitats. Along the Rocky Mountain Front (Front), however, limber pine also occurs at lower timberline as the dominant tree species, resulting in a diverse ecotone between Rocky Mountain forests and Great Plains grasslands. Here it constitutes an integral component of the landscape, influencing abiotic conditions and providing cover, shelter, and food for many wildlife species, including mule deer, elk and blue grouse.

The distribution of limber pine along the Front has changed dramatically over the last 150 years due to a combination of factors including but not limited to: climate change, fire frequency, occurrence of disease and human land use patterns. For example, early in this century, expansion of limber pine into grasslands was favored by fire suppression efforts. Yet these same stands are now showing increased stress and mortality, probably related to an infestation by pine blister rust and harsh abiotic conditions. The decline of limber pine along the Front may have dramatic impacts on the diversity of associated flora and fauna. Little is known, however, about the ecology of limber pine communities. Therefore, information on patterns and processes influencing limber pine is needed to aid resource managers in understanding the dynamics of habitat and wildlife on the Front.

Overall Objectives:

Research objectives include: (1) a description of current landscape patterns of limber pine stands on the Front, (2) identification of processes influencing limber pine distribution, and (3) information on the community ecology of limber pine relevant to management decisions. Existing information will be synthesized and field data will be collected to supplement an existing database of the area stored in a Geographic Information System (GIS). Proposed data layers include: 1) current and historic distribution of limber pine, based on existing resource databases, aerial photo and satellite imagery interpretation, dendrochronology, and historical maps and other documentation, 2) characterization of limber pine stands, including age, size, canopy coverage, and fire history, 3) description and quantification of flora and fauna associated with limber pine stands, and 4) geographic distribution of pine blister rust and other sources of disturbance.

The purpose of this preliminary report is to provide the BLM with a progress report on the information that has been gathered since the initiation of this research in summer 1996. All of the work contained herein will eventually be included in a dissertation and/or published works. Until that time, this information may not be considered fully reliable.

OVERVIEW

Reprinted from: Ayers, D. 1996. The Rocky Mountain Front: A Landscape in Transition. Fair Chase. Winter. pp. 16-19.

The Rocky Mountain Front: A Landscape in Transition

"The Front is a place where grasslands roll up against towering limestone cliffs, where endless shapes of clouds glide through deep blue skies, where rich habitats collide." -David Keller, 1995

In northcentral Montana, running north to south along the eastern fringe of the Rocky Mountains there lies a landscape unlike any other in the West. Here the sweeping Great Plains and the majestic Rocky Mountains collide, creating a diverse transition zone that appears frozen in time. Low human occupation has left most of this landscape undeveloped and human impacts have been slight. However, recent evidence has shown that this landscape has actually changed dramatically since first settlement by Euro-Americans in the 1860s. Over the last 130 years, the landscape of the Front has shifted from a homogenous fescue prairie to a more diverse landscape, patterned by patches of limber pine, aspen, and shrub communities. The factors causing this change are not yet fully understood. In this article, I present a possible explanation, founded on scientific research and principles of landscape and community ecology. I propose that historically, an array of ecological processes successfully prevented the invasion of tree and shrub communities into the grasslands. However, with the arrival of white settlers and their subsequent influence on ecosystem processes, conditions on the Front became more favorable for limber pine and other tree and shrub communities to establish. By understanding the factors that have shaped this landscape in the past, we might be able to identify future directions in management of land and resources on the Rocky Mountain Front.

THE HISTORICAL LANDSCAPE: BISON, FESCUE AND BLACKFEET

Humans have occupied the Rocky Mountain Front at least since the last glaciation, 11,000 years ago. The Great North Trail, along the base of limestone reefs on the Front, was a well-traveled passage that ran the full length of the Rocky Mountains, from what is now Canada to Mexico. Native American migrants, trappers, war parties and hunters made their way north and south along this trail. More permanent residents of the Front included the Blackfeet people. Many bands established winter and spring camps, following the migration of bison, their primary source of sustenance.

Anecdotal evidence from journals and oral history suggest that the landscape of the Front during this era was more homogenous than today with low habitat diversity. Descriptions suggest that grasslands stretched continuously from the vast prairie up into the foothills of the Rocky Mountains. The hillsides, valleys and ridgetops of the plains were bare, void of timber, and the vegetation was mostly short-grass and fescue prairie. Huge herds of wintering bison depended on these grasslands, as did other big game species, including elk, mule deer and pronghorn antelope.

Throughout the Great Plains, scientific research has shown that historically fires frequently swept over the grasslands, in some areas occurring as frequently as every five years. Although many fires were lightning-caused, some were also ignited by humans. The Blackfeet, like many other Native American tribes, intentionally ignited grasslands in an effort to attract game by increasing forage productivity. Grasslands evolved with these frequent fires and many grass species have adapted to this type of disturbance by depending on fire for maintaining productivity. When fires sweep across grasslands they typically remove all aboveground biomass, including dead grass, recycle nutrients, and kill off invasive trees and shrubs. For many forest-grassland transition zones, research has shown that fire has effectively sustained the prairie character by prohibiting invasion by fire-intolerant species. Fire may have also limited the invasion of limber pine on the Front. Here, the high frequency of fires probably prevented young saplings from reaching maturity and producing cones.

Fire was not the only process that made these grasslands inhospitable for limber pine. Bison were probably quite effective in preventing encroachment because they concentrate their grazing activities in areas where limber pine also tends to grow. Trampling, wallowing and heavy grazing by bison in these mutually preferred areas would have destroyed young seedlings. Bison may have also limited limber pine invasion indirectly; recent research suggests that their species-specific and seasonal grazing preferences created conditions that maintained the productivity of fescue prairie. Grazing disturbance, like fire, removes dead grass and promotes nutrient recycling, thereby establishing dominance of fescue prairie. The highly water-efficient fescue may have successfully outcompeted limber pine for water, thereby preventing germination and survival of limber pine. For several millennia, this disturbance regime of bison grazing and grassland fires restricted limber pine to bare, rocky outcrops, cliffs, and steep riparian corridors—areas absent of these disturbances. In fact, these areas are the only places on the Front where I have found limber pine trees that are older than 150 years.

LOSS OF THE FOOTHILL PRAIRIE: A CENTURY OF PINE INVASION

The invasion of limber pine into the grasslands on the Rocky Mountain Front probably began with Euro-American settlement in the 1860s. With suppression of fires and the elimination of bison grazing, conditions became more favorable for limber pine invasion. Bison were exterminated from the Front by 1883 and in the years following, were replaced by domestic livestock. By 1884 there were a reported 100,000 cattle, 60,000 sheep and 10,000 horses grazing on the Front. This intensive grazing pressure on fescue prairie was further compounded by a shift in the seasonal pattern of grazing from winter-only to year-round. This change resulted in a decline of fescue, leaving bare soils and plants that were less palatable. The change in species composition and abundance in the grasslands allowed for limber pine to successfully compete for the limited resource of water.

Heavy grazing also reduced fine fuels, which aided fire suppression efforts. The subsequent decline in fire frequency, intensity and spread enabled limber pine to survive long enough to produce cones and successfully

reproduce. As environmental conditions on the Front changed from inhospitable to those more favorable, limber pine was able to begin widespread invasion into grasslands. Research has shown that most large limber pine on the Front are between 90 and 120 years old, established during this time of intensive grazing and land settlement.

THE PRESENT LANDSCAPE: "THE AMERICAN SERENGETI"

These changes suggest that gradually, over the last century, fewer fires and year-long grazing has allowed for successful expansion of limber pine—from river corridors and rocky outcrops into the grasslands. As limber pine spread eastward, the conditions created by their presence created new wildlife habitat and probably increased the rate of invasion. Forested areas are known to ameliorate harsh winds and trap drifting snow, yielding greater soil moistures throughout spring and summer. This probably increased the rate of successful germination of limber pine and promoted a diversity of understory plants. On the fringes of these limber pine stands, aspen groves and shrub communities have established, subsequently adding to the diversity of the landscape. This diversity, in turn, has provided additional habitats for wildlife on the Front.

Wildlife biologists and land managers are only now beginning to understand the relationships of limber pine habitats and associated wildlife communities on the Front. The importance of limber pine as habitat differs among species but can be grouped into three categories: incidental, suitable, and obligatory. Incidental species might include grizzly bear and elk—species that do not appear to be dependent on limber pine but have been observed using the stands. The suitability of an area on the Front is improved by the presence of limber pine for species like mule deer and blue grouse, which are found in many different areas, but appear to prefer areas with limber pine. Clark's Nutcracker has evolved into an obligatory relationship with limber pine. Limber pine relies on Clark's Nutcracker, which cache between 70-90% of the annual seed production, for dispersal of its large, nutritious seeds, which have no other means of dispersal other than gravity. Clark's Nutcracker open the cones while they are still on the tree, stores up to 125 seeds in its pouch, and caches them in groups of two to a dozen in sites that are accessible during winter.

A LANDSCAPE STILL IN TRANSITION: HERE TODAY, GONE TOMORROW?

As local residents and visitors to the Front today can attest, the landscape is diversified by its many habitats. The ridgetops and hillsides support expanding stands of limber pine. These stands are lined with patches of shrubs like rose, serviceberry, shrubby cinquefoil and chokecherry. In the moister ravines, aspen groves grow thick and provide a cool refuge during hot summer months. The patchwork of these different types of habitats supports an array of

wildlife species including elk, mule deer, grizzly bear, wolves, coyotes, blue grouse, Bohemian waxwing, mountain bluebird, mountain lions and badgers, as well as many other species. Probably because of this habitat diversity, the Front today supports both higher populations and a greater diversity of wildlife than recorded by settlers 130 years ago. Hunters, hikers, biologists, writers, locals and visitors have all come to love and appreciate this incredible diversity and scenery of the Rocky Mountain Front.

The environmental conditions of the Front, as we understand them today, suggest that limber pine has become an integral component of the landscape, by defining new habitats and supporting wildlife. But this is not the final picture; the landscape is still changing. Ecological processes are shifting yet again, and limber pine appears to be dying out. Since the early 1970s, an infestation of blister rust has infected many stands along the Front, gradually killing them and leaving only "ghost" stands. These foreboding changes may be related to human land use practices, climate change or possibly new, unknown, inhospitable conditions. Without fully understanding the historic processes that led to the invasion of limber pine, it will be difficult to ascertain what the future landscape and wildlife of the Front will be. Quite possibly in another 130 years, biologists will describe the landscape of the Rocky Mountain Front, and hypothesize on the ecological processes that caused the shift from a landscape of limber pine foothills with a diverse array of wildlife to the present landscape, one perhaps of thick Douglas-fir forests, or perhaps maybe once again, of vast prairies of fescue grassland, treeless and bare, except for a scattered few, old limber pine and the occasional bull elk.

STUDY AREA DESCRIPTION:

The Rocky Mountain Front is geographically delineated by the Continental Divide to the west and south, US Highways 200, 89, and 287 to the east, and the Canadian border to the north (Figure 1). The overall study area encompasses the Teton River and Birch Creek watersheds (Figure 2). Sites of specific interest include Theodore Roosevelt Memorial Ranch (Boone and Crockett Club), Blackleaf Wildlife Management Area (Montana Fish, Wildlife, and Parks), Blindhorse Outstanding Natural Area (Bureau of Land Management), and Pine Butte Swamp Preserve (The Nature Conservancy). Each of these sites is representative of limber pine communities on the Front.

Abiotic conditions on the Front are extreme, particularly in winter, and in many ways resemble those of timberline environments (Figure 3). The Front is drier, windier, and colder than most regions west of the Continental Divide. Long, cold winters and short, warm summers characterize this continental climate. Annual precipitation ranges from 30-90 cm along the limestone reefs (Figure 4) (Group 1990). Snow accounts for 45-75% of annual precipitation and may fall during any month of the year, although the greatest amount of precipitation occurs between April and July (Moeckel 1997). Temperatures vary considerably from one area to the next and can range from -40° to 37°C annually (Aune and Kasworm 1989). The growing season varies from approximately 110 days in Choteau to 50 days in areas closer to the Divide (Dubois 1984). On the Front, both winter and summer are drought periods, especially in times of high winds. Northwestern winds are especially strong along the faces of the limestone cliffs (Figure 5), marking the edge of the foothills and the mountains. These strong, year-round, dry, uni-directional winds reduce water availability and result in low mean annual temperatures, as well as highly variable temperatures (Anonymous 1980). Chinook winds also occur frequently on the Front (Figure 6), especially in winter (Caprio et al. 1981, BLM 1992). A Chinook can increase air temperatures as much as 25°C in one hour and have wind speeds exceeding 56 m/s (Brinkman 1971). In "Chinook belts", snow typically lasts only a few days and bare ground is present throughout most of winter (Anonymous 1980). As a result, Chinook winds are often associated with drought conditions (Nkemdirim 1991).

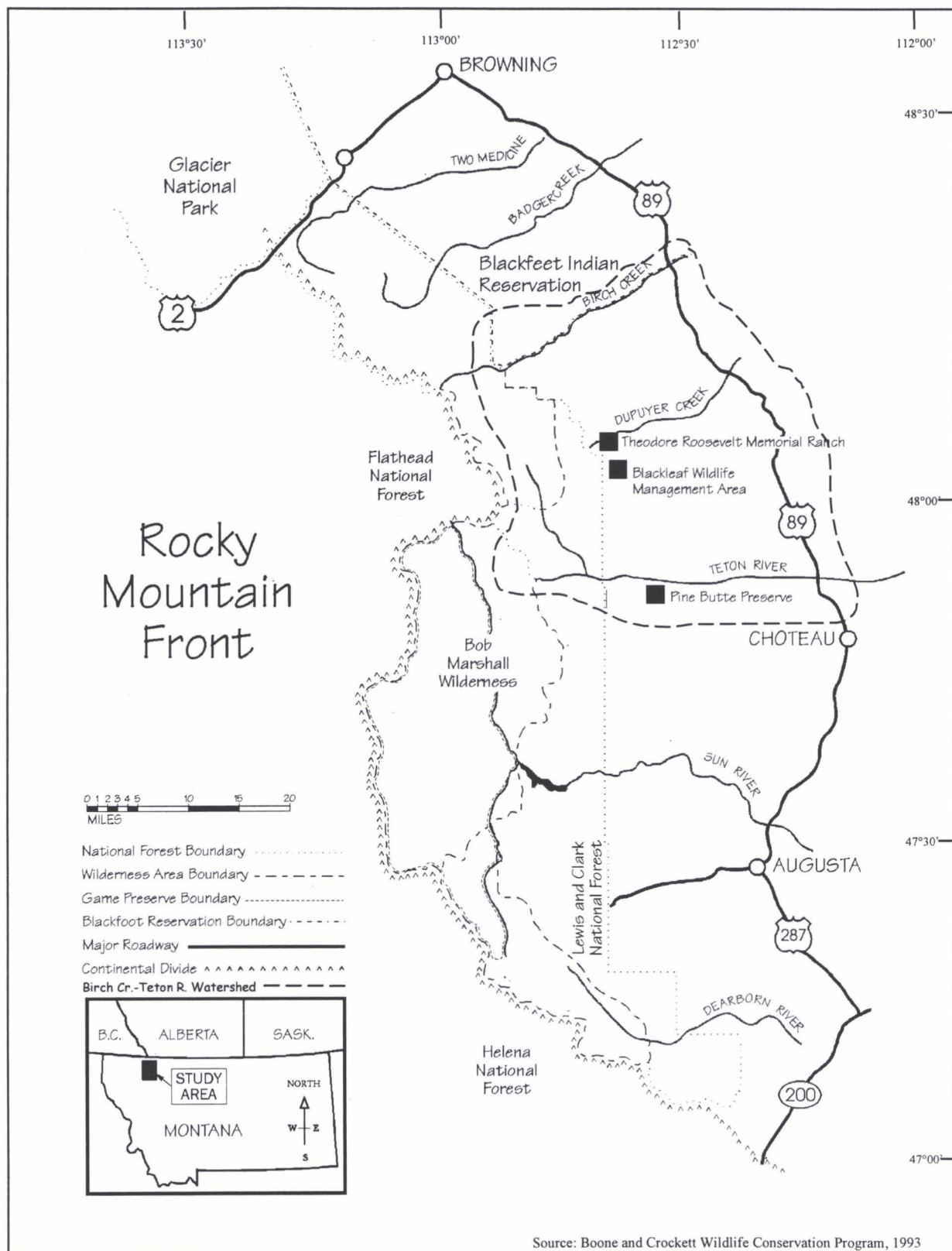


Figure 1. Study area on Montana's Rocky Mountain Front.

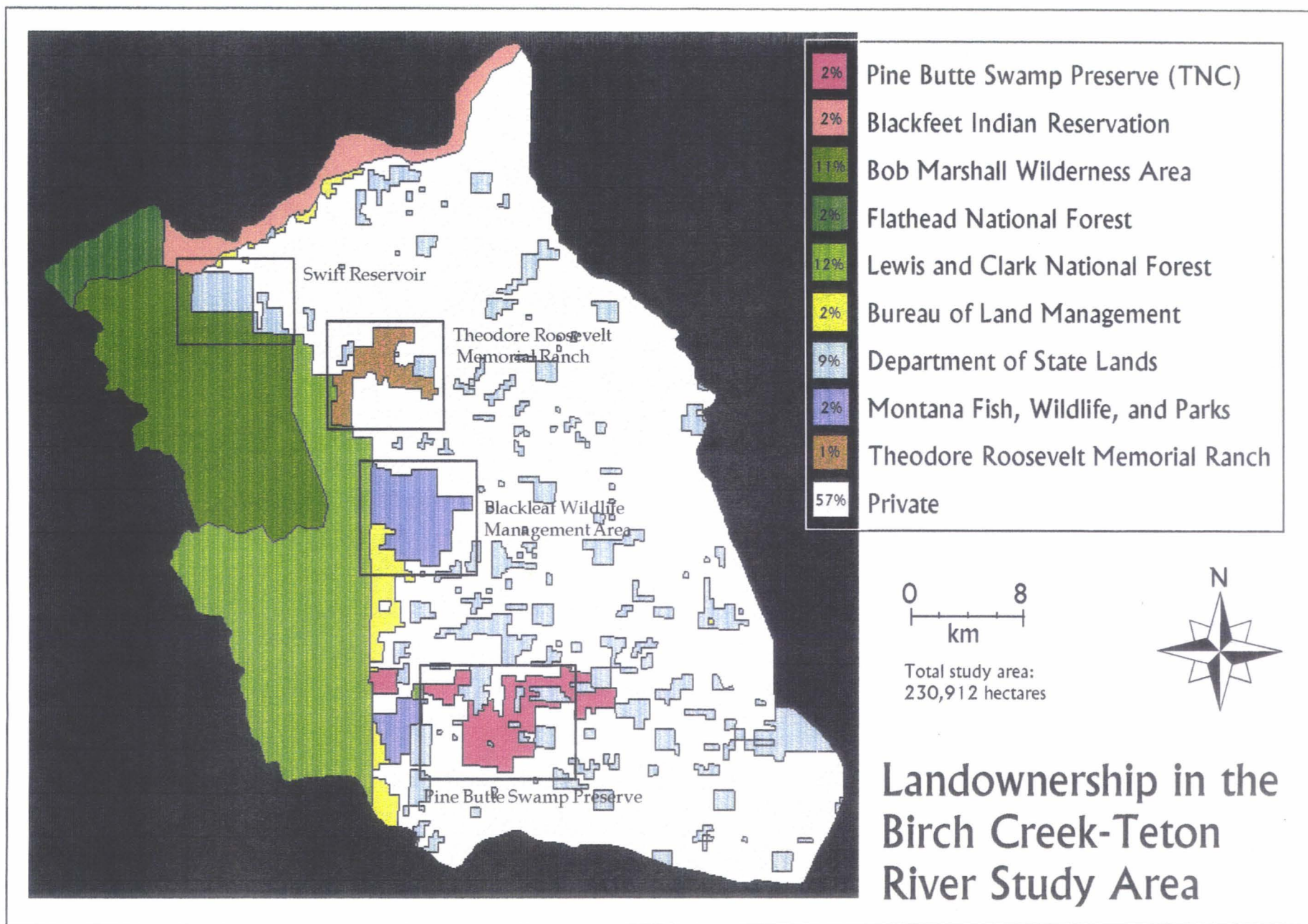
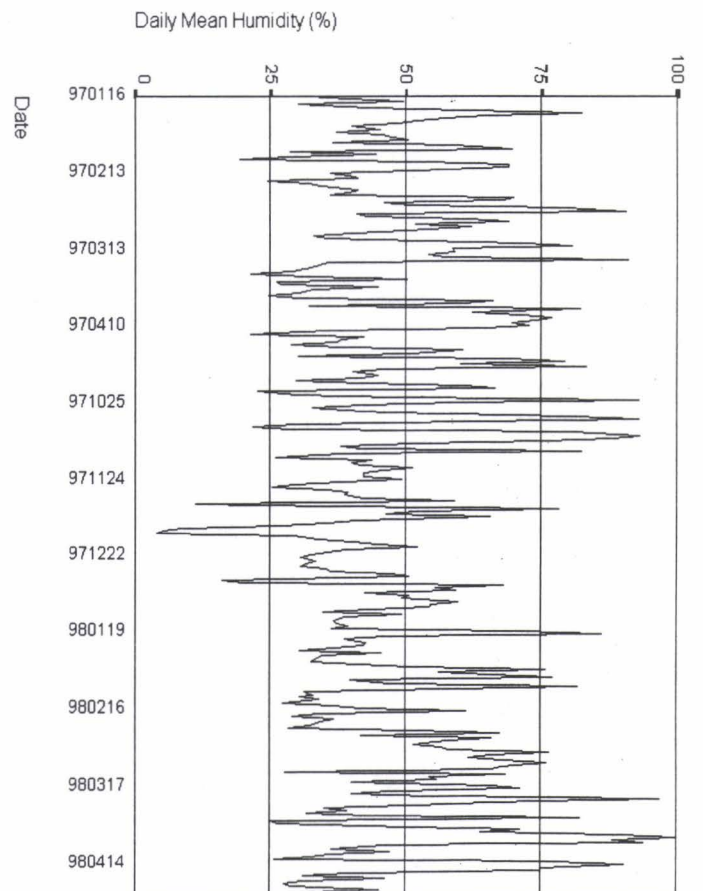
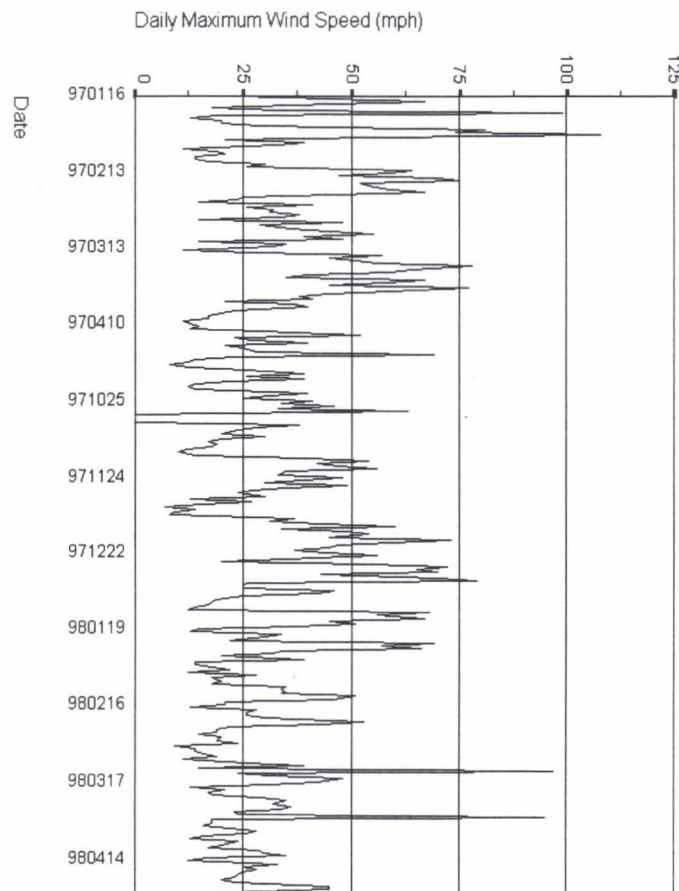
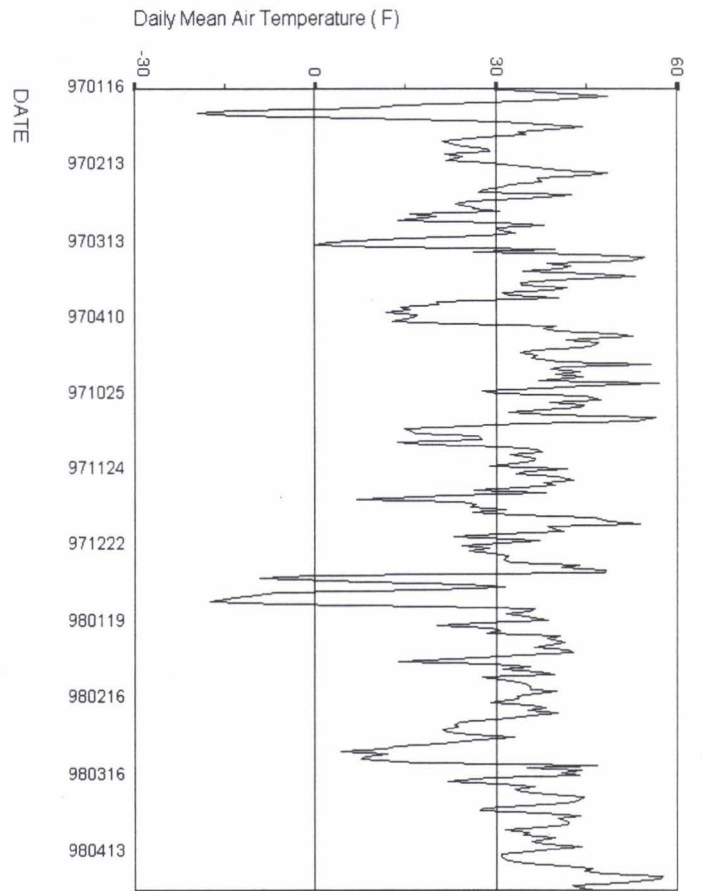
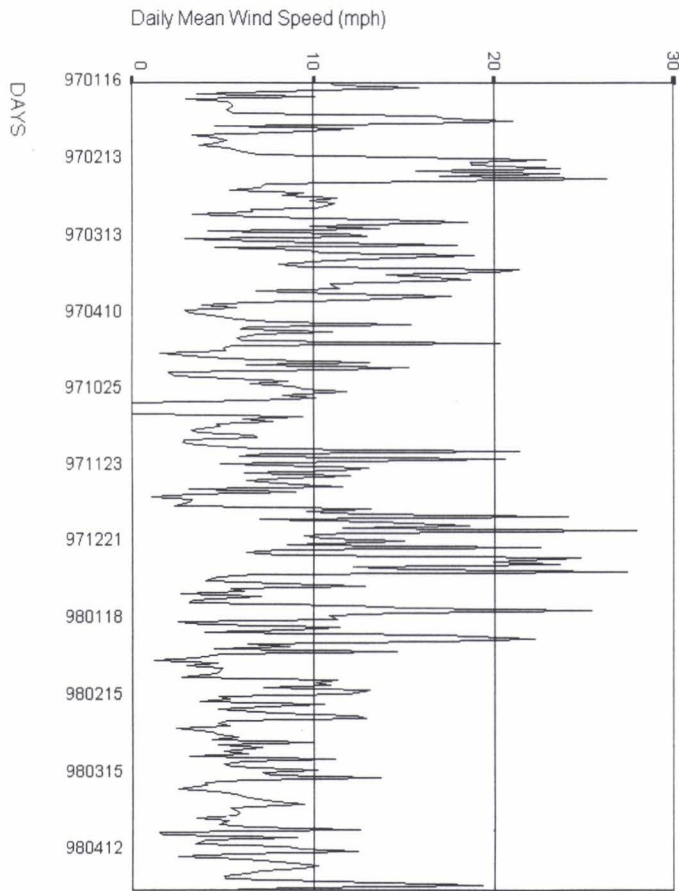
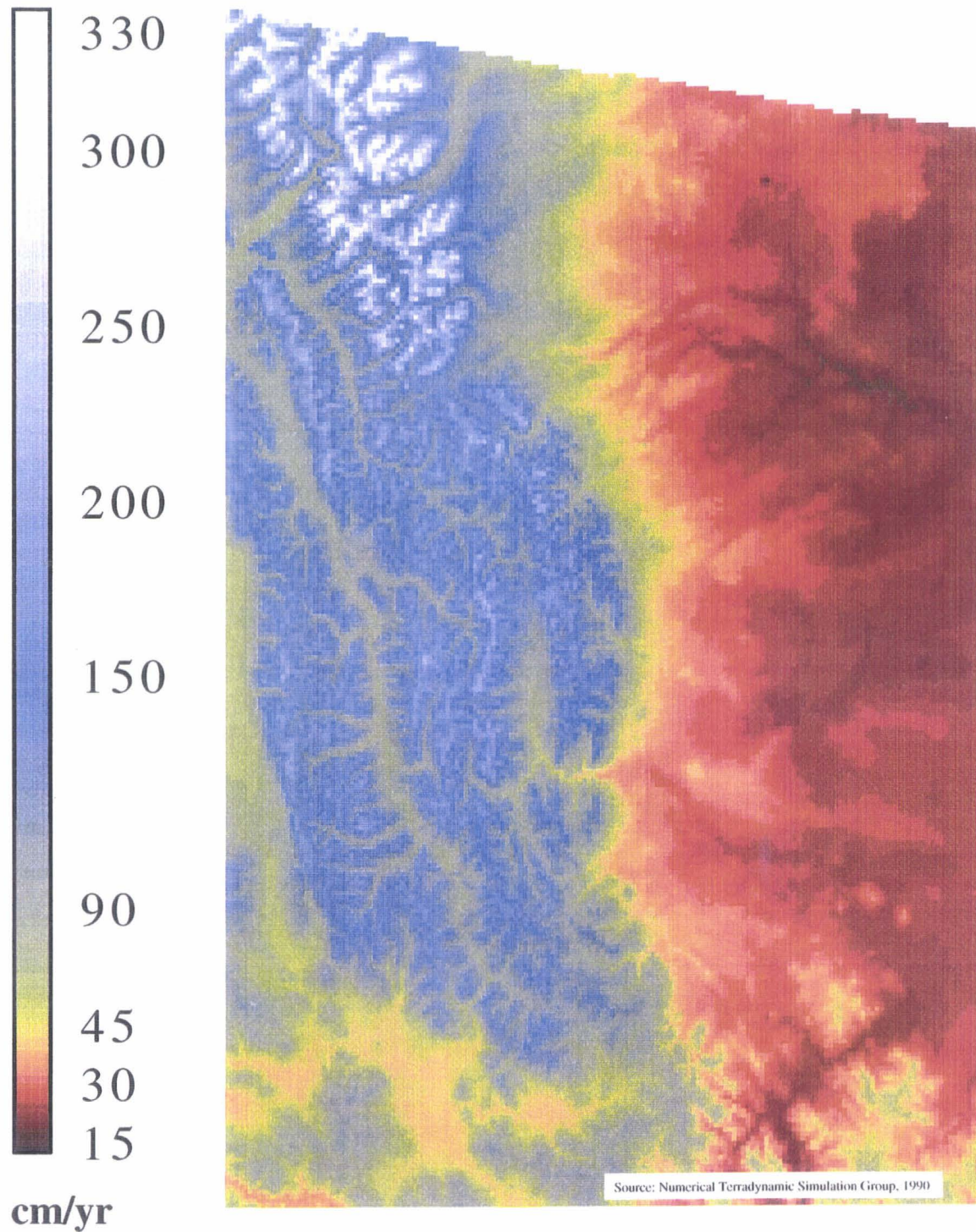


Figure 2: Research sites in the Birch Creek-Teton River Study Area for community level analyses.

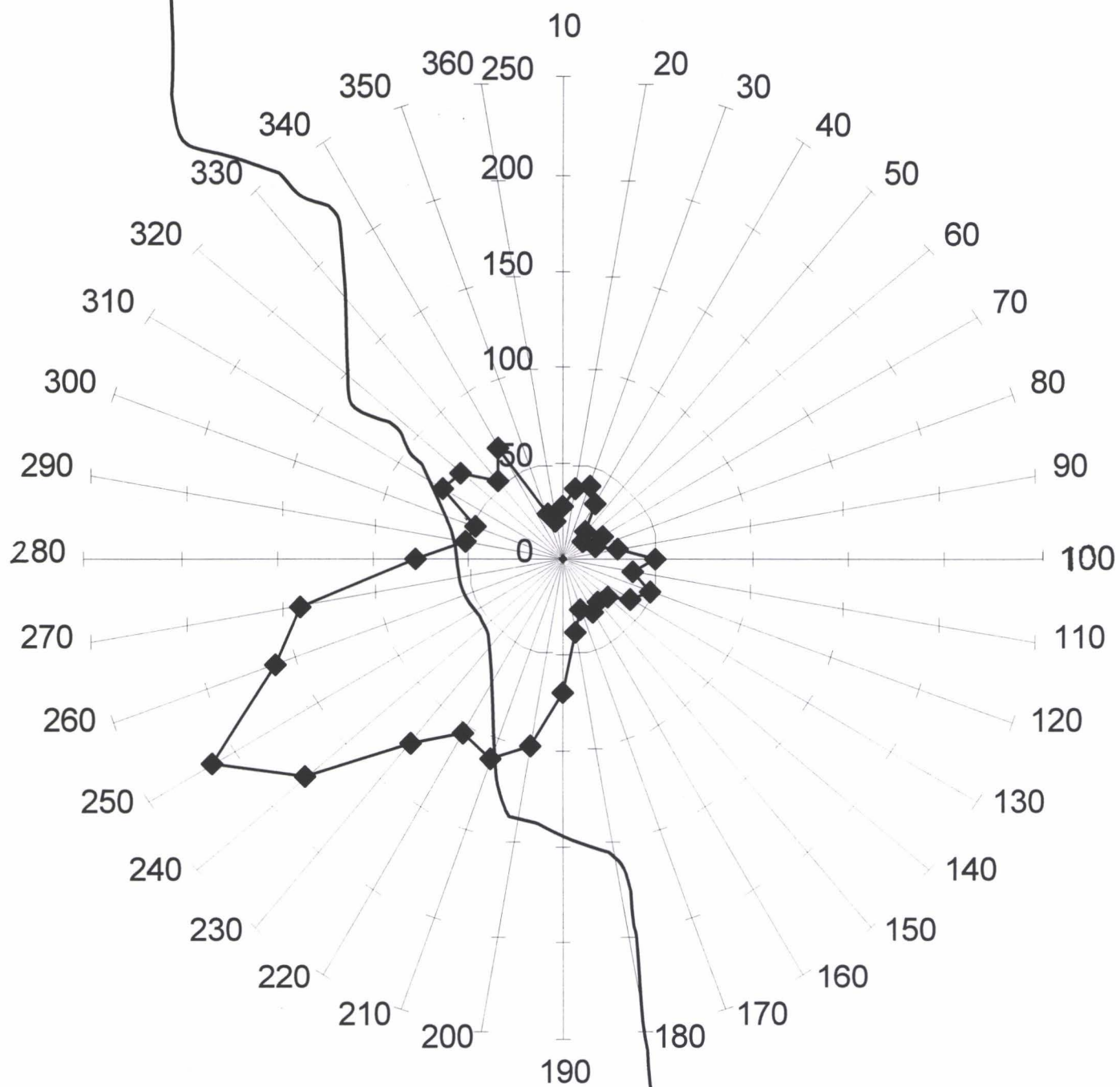


Annual Precipitation on the Rocky Mountain Front



DOMINANT WIND DIRECTION

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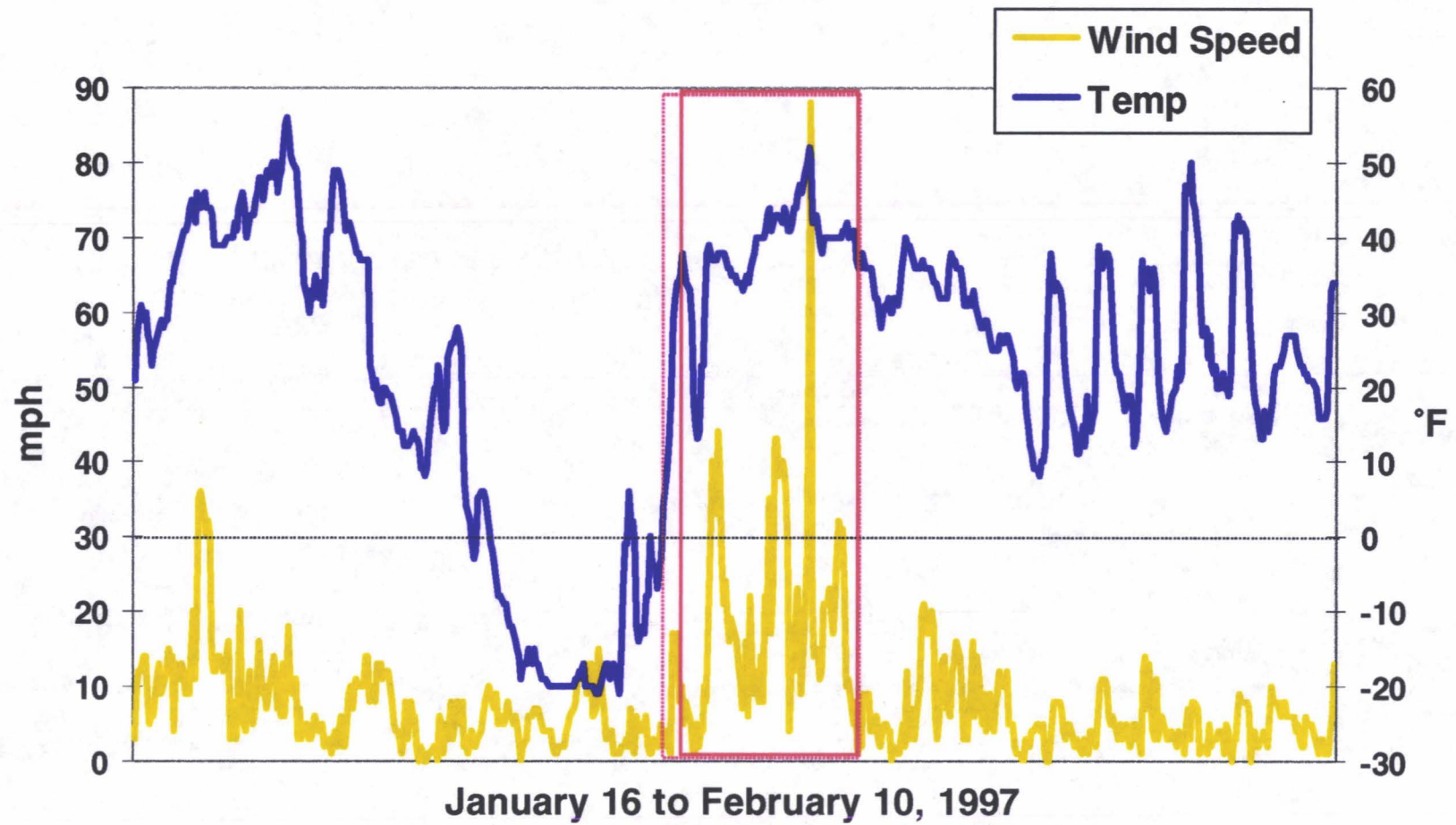


S

ORIENTATION
OF FRONT

“CHINOOK” ON RMF

Wind and Temperature



VEGETATION DESCRIPTION

Botanically, the Front is the ecotone between the Rocky Mountain forests and the Great Plains grasslands (Barker and Whitman 1988, Demarchi and Lea 1992). Over 60% of the land cover is fescue prairie, interspersed by shrub patches, limber pine stands, aspen groves and riparian corridors (Redmond and Prather 1996). Over the last 150 years, changes in fire frequency and intensity (Arno 1980), climate, disease, and human land use patterns (Baumeister et al. 1996) have dramatically altered the historic composition and structure of flora and fauna of the Front (Ayers 1996). Most noticeable is the invasion of the fescue prairie by native fire-intolerant limber pine, which has created a savanna-like landscape along the entire Front, from central Montana into Canada.

Vegetation of the Front has been mapped by various agencies at different scales. Site-specific maps have been developed from field data for Theodore Roosevelt Memorial Ranch and Pine Butte Preserve. Aerial photos from 1987 were used by the USFS to develop vegetation cover classes for the Birch Creek-Teton River Bear Management Unit. The Wildlife Spatial Analysis Lab at The University of Montana developed a vegetation map for the entire Northern Region of the USFS, which encompasses the RMF, from 1992 satellite images. All of these maps have been digitized and brought into a GIS managed by the Boone and Crockett Wildlife Conservation Program at The University of Montana. I am currently using the field-tested and aerial photo interpreted maps to calibrate and improve on the satellite-generated map. Current vegetation cover types are presented for the study area (Figures 7-9) and Blindhorse ONA (Figure 10). Description of land cover types follows.

Rock, snow, barren: All terrestrial lands with less than 15% vegetative cover.

Broadleaf Forest: Includes aspen and upland cottonwood communities.

Limber Pine: Includes all evergreen, forested stands with at least 15% canopy cover, >40% of which is limber pine.

Other Conifer: All evergreen forests with at least 15% canopy cover and with <40% cover of limber pine. Common species include lodgepole pine, Douglas-fir, Engelmann spruce, sub-alpine fir, and whitebark pine.

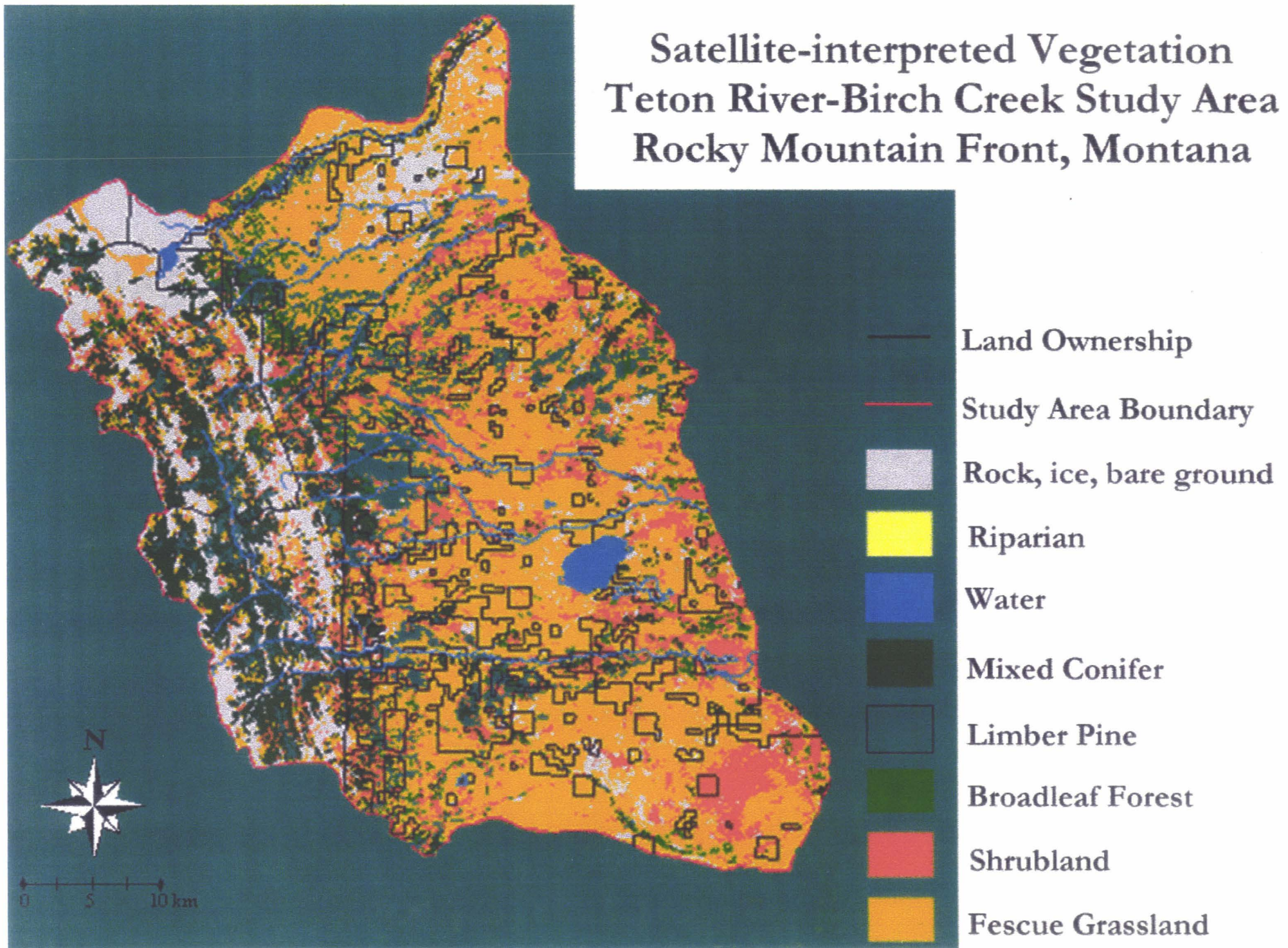
Shrubland: All lands dominated by woody, perennial shrubs. Common species include chokecherry, serviceberry, buffaloberry, wild rose, and shrubby cinquefoil.

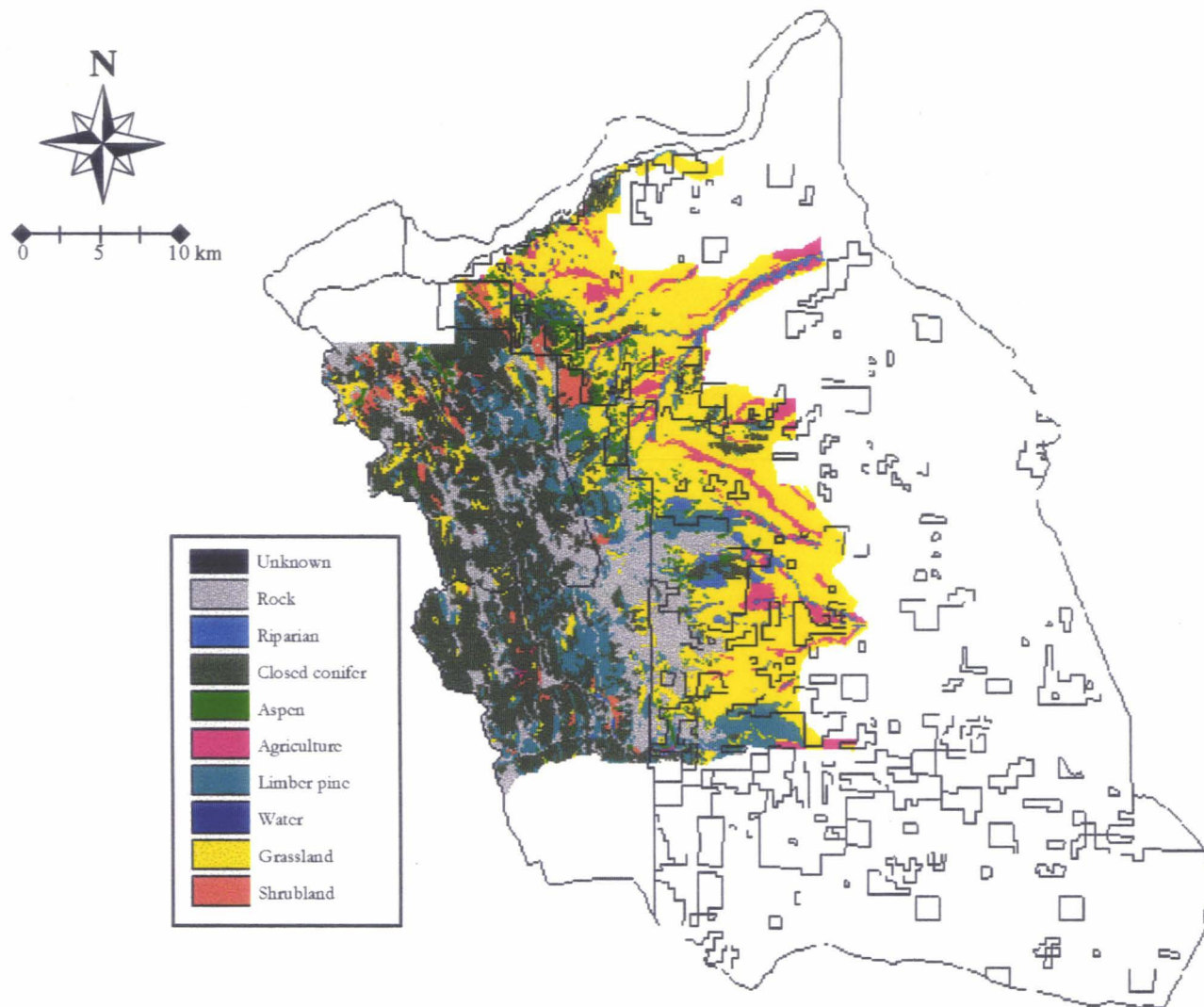
Fescue grassland: All lands dominated by grass. Most lands are fescue dominated (rough fescue and idaho fescue). Agricultural lands are also included in this category.

Riparian: Includes all cover types associated with water including: riparian corridors dominated by cottonwood, aspen, willow, swamps, marshes, wetlands, etc.

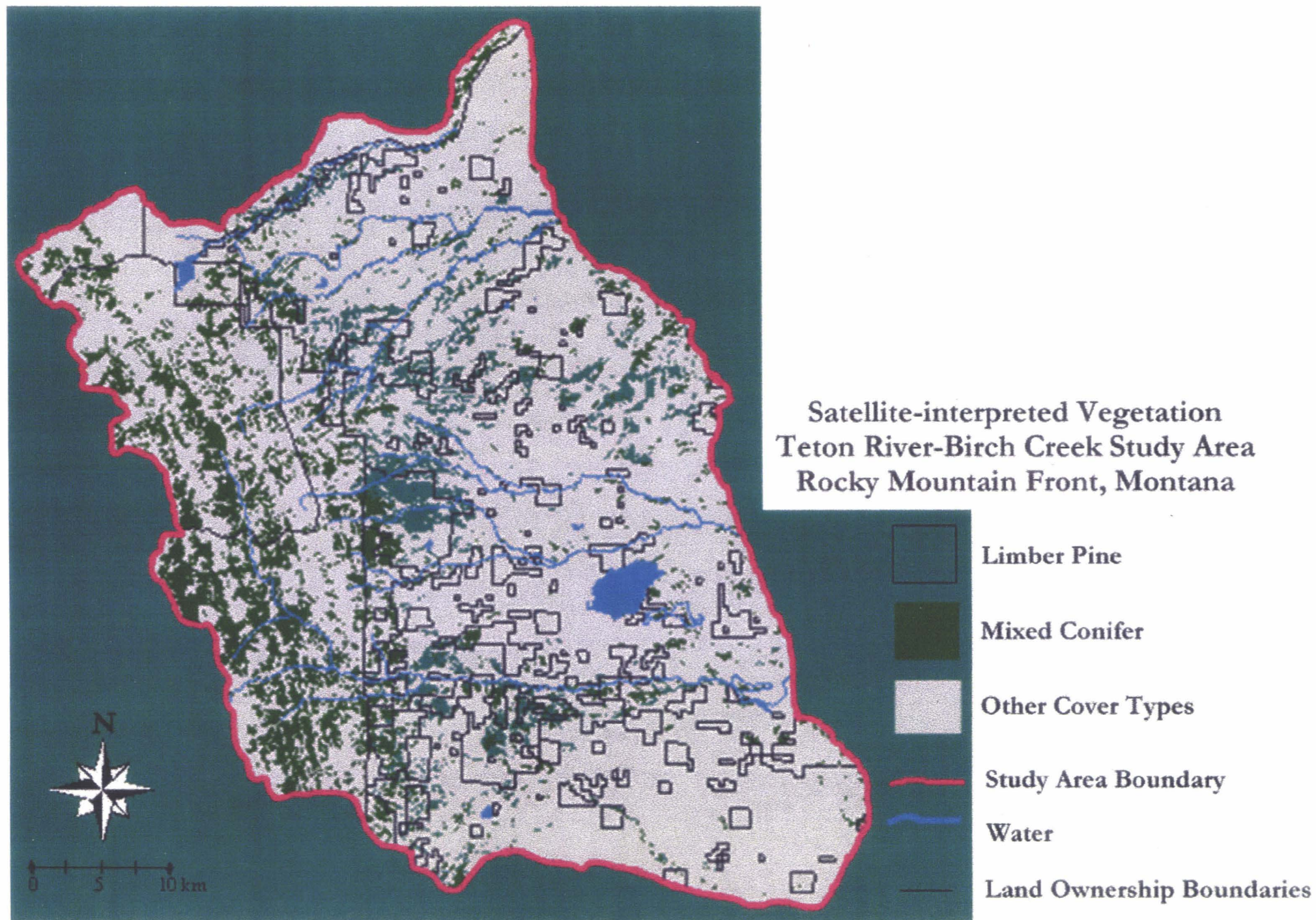
Water: All open water found in ponds, lakes, and reservoirs.

Satellite-interpreted Vegetation Teton River-Birch Creek Study Area Rocky Mountain Front, Montana





Vegetation Types from Birch-Teton BMU, CEM-model 1985





Satellite-interpreted Vegetation
Blind Horse Outstanding
Natural Area (BLM)
Rocky Mountain Front

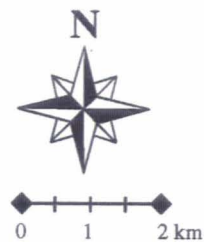
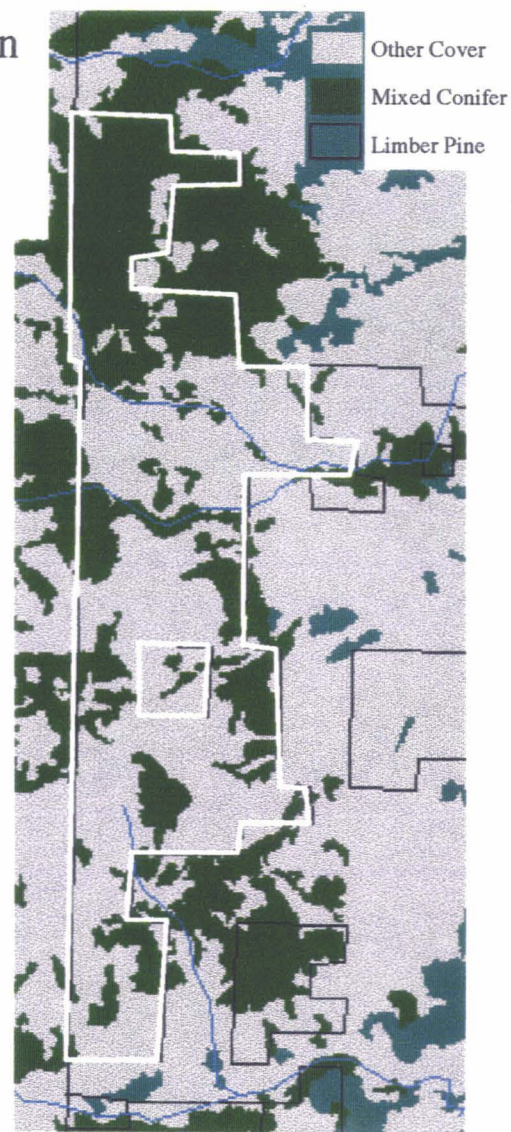


Table 1: COMPREHENSIVE SPECIES LIST:

(Adapted from Hurlburt (1996) and Lesica and Hanna (1996).)

6 letter code	SCIENTIFIC NAME	COMMON NAME
ACEGLA	<i>Acer glabrum</i>	Rocky mountain maple
ACHMIL	<i>Achillea millefolium</i>	Yarrow
ACTRUB	<i>Actaea rubra</i>	Baneberry
AGOGLA	<i>Agoseris glauca</i>	False dandelion
AGRCAN	<i>Agropyron caninum</i>	Awned wheatgrass
AGRDAS	<i>Agropyron dasytachyum</i>	Thick-spiked wheatgrass
AGRINT	<i>Agropyron intermedium</i>	Intermediate wheatgrass
AGRREP	<i>Agropyron repens</i>	Quackgrass
AGRSUB	<i>Agropyron subsecundum</i>	Bearded wheatgrass
AGRTA	<i>Agropyron trachycaulum</i>	Braid-glumed wheatgrass
AGRTRC	<i>Agropyron trichophorum</i>	Pubescent wheatgrass
AGRALB	<i>Agrostis alba</i>	Redtop
AGRSCA	<i>Agrostis scabra</i>	Rough bentgrass-ticklegrass
ALLCER	<i>Allium cernuum</i>	Nodding onion
ALLSCH	<i>Allium schoenoprasum</i>	Chives
ALOAQ	<i>Alopecurus aequalis</i>	Short-awn foxtail
ALOALP	<i>Alopecurus alpinus</i>	Alpine foxtail
ALOGEN	<i>Alopecurus geniculatus</i>	Water foxtail
ALYALY	<i>Alyssum alyssoides</i>	Pale alyssum
AMEALN	<i>Amelanchier alnifolia</i>	Serviceberry
ANAMAR	<i>Anaphalis margaritacea</i>	Pearly everlasting
ANDFIL	<i>Androsace filiformis</i>	Fairy-candelabra
ANDOCC	<i>Androsace occidentalis</i>	Western fairy candelabra
ANDSEP	<i>Androsace septentrionalis</i>	Northern fairy candelabra
ANEMUL	<i>Anemone multifida</i>	Cliff anemone
ANENUT	<i>Anemone nuttalliana</i>	Pasque flower
ANGARG	<i>Angelica arguta</i>	Sharptoothed angelica
ANTANA	<i>Antennaria anaphaloides</i>	Tall pussytoes
ANTNEG	<i>Antennaria neglecta</i>	Field pussytoes
ANTRAC	<i>Antennaria racemosa</i>	Raceme pussytoes
ANTROS	<i>Antennaria rosea</i>	Rose pussytoes
APOAND	<i>Apocynum androsaemifolium</i>	Dogbane
AQUFLA	<i>Aquilegia flavescens</i>	Yellow columbine
ARAGLA	<i>Arabis glabra</i>	Tower mustard
ARASPA	<i>Arabis hirsuta</i>	Hairy rockcress
ARANUT	<i>Arabis nuttallii</i>	Nuttall's rockcress
ARCMIN	<i>Arctium minus</i>	Common burdock
ARCUVA	<i>Arctostaphylos uva-ursi</i>	Kinnikinnick
ARECON	<i>Arenaria congesta</i>	Ballhead sandwort
ARELAT	<i>Arenaria lateriflora</i>	Side-flowering sandwort
ARNLAT	<i>Arnica latifolia</i>	Broadleaf arnica
ARNSOR	<i>Arnica sororia</i>	Twin arnica
ARTCAM	<i>Artemisia campestris</i>	Pacific sagewort

6 letter code	SCIENTIFIC NAME	COMMON NAME
ARTCAN	<i>Artemisia cana</i>	Silver sage
ARTDRA	<i>Artemisia dracuncululus</i>	Tarragon
ARTFRI	<i>Artemisia frigida</i>	Fringed sage
ARTLUD	<i>Artemisia ludoviciana</i>	Prairie sagewort
ARTMIC	<i>Artemisia michauxiana</i>	Michaux mugwort
ARTTRI	<i>Artemisia tridentata</i>	Big sagebrush
ASTCON	<i>Aster conspicuus</i>	Showy aster
ASTEAT	<i>Aster eatonii</i>	Eaton's aster
ASTFAL	<i>Aster falcatus</i>	Little gray aster
ASTFOL	<i>Aster foliaceus</i>	Leafy aster
ASTHES	<i>Aster hesperius</i>	Siskiyou aster
ASTJUN	<i>Aster junciformis</i>	Rush aster
ASTLAE	<i>Aster laevis</i>	Smooth aster
ASTOCC	<i>Aster occidentalis</i>	Western mountain aster
ASTAGR	<i>Astragalus agrestis</i>	Field milkvetch
ASTCAN	<i>Astragalus canadensis</i>	Canada milkvetch
ASTCRA	<i>Astragalus crassicaupus</i>	Groundplum milkvetch
ASTDRU	<i>Astragalus drummondii</i>	Drummond's milkvetch
ASTGIL	<i>Astragalus gilviflorus</i>	Plains orophaca
ASTMIC	<i>Astragalus microcystis</i>	Bladdery milkvetch
ASTVEX	<i>Astragalus vexilliflexus</i>	Bentflowered milkvetch
BALINC	<i>Balsamorhiza incana</i>	Hoary balsamroot
BALSAG	<i>Balsamorhiza sagittata</i>	Arrowleaf balsamroot
BECSYZ	<i>Beckmannia syzigachne</i>	American sloughgrass
BESWYO	<i>Besseyia wyomingensis</i>	Wyoming kittentail
BETFO	<i>Betula fontinalis</i>	Water birch
BROANO	<i>Bromus anomalus</i>	Nodding brome
BROCAR	<i>Bromus carinatus</i>	Mountain brome
BROINE	<i>Bromus inermis</i>	Smooth brome
BROVUL	<i>Bromus vulgaris</i>	Columbia brome
BUPAME	<i>Bupleurum americanum</i>	American thorough-wax
CALCAN	<i>Calamagrostis canadensis</i>	Bluejoint reedgrass
CALINE	<i>Calamagrostis inexpansa</i>	Northern reedgrass
CALPUR	<i>Calamagrostis purpurascens</i>	Purple reedgrass
CALRUB	<i>Calamagrostis rubescens</i>	Pinegrass
CAMMIC	<i>Camelina microcarpa</i>	Littlepod falseflax
CAMROT	<i>Campanula rotundifolia</i>	Harebell
CARNUT	<i>Carduus nutans</i>	Musk thistle
CARAQU	<i>Carex aquatilis</i>	Water sedge
CARCON	<i>Carex concinnoides</i>	Northwestern sedge
CARFIL	<i>Carex filifolia</i>	Thread-leaved sedge
CARGEY	<i>Carex geyeri</i>	Elk sedge
CARHOO	<i>Carex hoodii</i>	Hood's sedge
CARLAN	<i>Carex lanuginosa</i>	Woolly sedge
CARNAR	<i>Carex nardina</i>	Spikenard sedge
CAROB	<i>Carex obtusata</i>	Blunt sedge
CAROED	<i>Carex oederi</i>	Green sedge
CARPRA	<i>Carex praegracilis</i>	Clustered field sedge

6 letter code	SCIENTIFIC NAME	COMMON NAME
CARRAY	<i>Carex raynoldsii</i>	Raynolds' sedge
CARROI	<i>Carex rossii</i>	Ross sedge
CARROS	<i>Carex rostrata</i>	Beaked sedge
CARSCI	<i>Carex scirpoidea</i>	Canadian Single-spiked sedge
CARSCO	<i>Carex scopularum</i>	Rocky Mountain sedge
CARSPR	<i>Carex sprengelii</i>	Sprengel's sedge
CARCAR	<i>Carum carvii</i>	Caraway
CASCUS	<i>Castilleja cusickii</i>	Cusick's paintbrush
CASMIN	<i>Castilleja minata</i>	Scarlet paintbrush
CASNIV	<i>Castilleja nivea</i>	Snow paintbrush
CEAVEL	<i>Ceanothus velutinus</i>	Mountain balm
CENMAC	<i>Centaurea maculosa</i>	Spotted knapweed
CERARV	<i>Cerastium arvense</i>	Field chickweed
CHEALB	<i>Chenopodium album</i>	Lambsquarter
CHRLEU	<i>Chrysanthemum leucanthemum</i>	Oxeye-daisy
CICDOU	<i>Cicuta douglasii</i>	Douglas waterhemlock
CIRARV	<i>Cirsium arvense</i>	Canada thistle
CIRFLO	<i>Cirsium flodmanii</i>	Flodman's thistle
CIRUND	<i>Cirsium undulatum</i>	Wavy-leaved thistle
CIRVUL	<i>Cirsium vulgare</i>	Bull thistle
CLALAN	<i>Claytonia lanceolata</i>	Spring beauty
CLECOL	<i>Clematis columbiana</i>	Columbia clematis
CLEHIR	<i>Clematis hirsutissima</i>	Vaseflower clematis
CLELIG	<i>Clematis ligusticifolia</i>	Western virgins-brower
COLPAR	<i>Collinsia parviflora</i>	Small blue-eyed mary
COLLIN	<i>Collomia linearis</i>	Narrow-leaf collomia
COMUMB	<i>Comandra umbellata</i>	Bastard toad-flax
CONWIL	<i>Conimitella williamsii</i>	Conimitella
CONARV	<i>Convolvulus arvensis</i>	Field morning-glory
CORSTR	<i>Corallorhiza striata</i>	Striped coral-root
CORSTO	<i>Cornus stolonifera</i>	Red osier dogwood
CRACOL	<i>Crataegus columbiana</i>	Columbia hawthorn
CREACU	<i>Crepis acuminata</i>	Tapertip hawksbeard
CRERUN	<i>Crepis runcinata</i>	Dandelion hawksbeard
CRETEC	<i>Crepis tectorum</i>	Annual hawksbeard
CRYSPI	<i>Cryptantha spiculifera</i>	Bristly cryptantha
CYNOFF	<i>Cynoglossum officinale</i>	Common hound's tongue
CYPMON	<i>Cypripedium montanum</i>	Mountain lady's- slipper
DACGLO	<i>Dactylis glomerata</i>	Orchardgrass
DALCAN	<i>Dalea candida</i>	White prairie-clover
DALPUR	<i>Dalea purpurea</i>	Purple prairie clover
DANCAL	<i>Danthonia californica</i>	California danthonia
DANINT	<i>Danthonia intermedia</i>	Timber oatgrass
DANPAR	<i>Danthonia parryi</i>	Parry's oatgrass
DANSPI	<i>Danthonia spicata</i>	Poverty oatgrass
DANUNI	<i>Danthonia unispicata</i>	Onespike oatgrass
DELBIC	<i>Delphinium bicolor</i>	Larkspur
DESCES	<i>Deschampsia cespitosa</i>	Tufted hair-grass

6 letter code	SCIENTIFIC NAME	COMMON NAME
DESPIN	<i>Descuraiana pinnata</i>	Western tansymustard
DISTRA	<i>Disporum trachycarpum</i>	Wartberry fairy-bell
DISSTR	<i>Distichlis stricta</i>	Seashore saltgrass
DODCON	<i>Dodecatheon conjugens</i>	Slimpod shooting star
DOUMON	<i>Douglasia montana</i>	Mountain douglasia
DRAAPI	<i>Draba apiculata</i>	Pointed draba
DRAVER	<i>Draba verna</i>	Spring whitlow-grass
ELACOM	<i>Elaeagus commutata</i>	Silverberry
ELEPAL	<i>Eleocharis palustris</i>	Common spike rush
ELYSAN	<i>Elymus canadensis</i>	Canada wildrye
ELYCIN	<i>Elymus cinereus</i>	Giant wildrye
ELYGLA	<i>Elymus glaucus</i>	Blue wild rye
ELYSMI	<i>Elymus smithii</i>	Western wheatgrass
ELYSPI	<i>Elymus spicata</i>	Bluebunch wheatgrass
EPIANA	<i>Epilobium anagallidifolium</i>	Alpine willow-herb
EPICIL	<i>Epilobium ciliatum</i>	Autumn willow-herb
EPIGLA	<i>Epilobium glaberrimum</i>	Smooth willow-herb
EPILAT	<i>Epilobium latifolium</i>	Red willow-herb
EPISUF	<i>Epilobium suffruticosum</i>	Shrubby willow-herb
EQUARV	<i>Equisetum arvense</i>	Field horsetail
ERICAE	<i>Erigeron caespitosus</i>	Tufted fleabane
ERICOM	<i>Erigeron compositus</i>	Cut-leaved daisy
ERICOU	<i>Erigeron coulteri</i>	Coulter's fleabane
ERIFIL	<i>Erigeron filifolius</i>	Threadleaf fleabane
ERIGLA	<i>Erigeron glabellus</i>	Smooth daisy
ERIOCH	<i>Erigeron ochroleucus</i>	Buff fleabane
ERIPUM	<i>Erigeron pumilis</i>	Shaggy fleabane
ERISPE	<i>Erigeron speciosus</i>	Showy fleabane
ERISUB	<i>Erigeron subtrinervis</i>	Three-veined fleabane
ERIHHER	<i>Eriogonum heracleoides</i>	Wyeth buckwheat
ERIFLA	<i>Eriogonum flavum</i>	Yellow buckwheat
ERIHOW	<i>Eritrichium howardii</i>	Alpine forget-me-not
ERYINC	<i>Erysimum inconspicuum</i>	Small flowered wallflower
ERYREP	<i>Erysimum repandum</i>	Spreading wallflower
ERYGRA	<i>Erythronium grandiflorum</i>	Glacier-lily
EUPESU	<i>Euphorbia esula</i>	Leafy spurge
FESIDA	<i>Festuca idahoensis</i>	Idaho fescue
FESPRA	<i>Festuca pratensis</i>	Meadow fescue
FESRUB	<i>Festuca rubra</i>	Red fescue
FESSCA	<i>Festuca scabrella</i>	Rough fescue
FRAVES	<i>Fragaria vesca</i>	Woods strawberry
FRAVIR	<i>Fragaria virginiana</i>	Virginia strawberry
FRASPE	<i>Frasera speciosa</i>	Giant frasera
FRIPUD	<i>Fritillaria pudica</i>	Yellow bells
GAIARI	<i>Gaillardia aristata</i>	Blanket-flower
GALAPA	<i>Galium aparine</i>	Goose-grass
GALBOR	<i>Galium boreale</i>	Northern bedstraw
GAUCOC	<i>Gaura coccinea</i>	Scarlet gaura

6 letter code	SCIENTIFIC NAME	COMMON NAME
GENAFF	<i>Gentiana affinis</i>	Pleated gentian
GENCAL	<i>Gentiana calycosa</i>	Explorer's gentian
GENAMA	<i>Gentianella amarella</i>	Northern gentian
GERBIC	<i>Geranium bicknellii</i>	Bicknell's geranium
GERRIC	<i>Geranium richardsonii</i>	White geranium
GERVIS	<i>Geranium viscosissimum</i>	Sticky geranium
GEUALE	<i>Geum aleppicum</i>	Yellow avens
GEURIV	<i>Geum rivale</i>	Water avens
GEUTRI	<i>Geum triflorum</i>	Prairie smoke
GLYELA	<i>Glyceria elata</i>	Tall mannagrass
GLYGRA	<i>Glyceria grandis</i>	American mannagrass
GLYSTR	<i>Glyceria striata</i>	Fowl mannagrass
GOOOBL	<i>Goodyera oblongifolia</i>	Western rattlesnake-plantain
GRISQU	<i>Grindelia squarrosa</i>	Curlycup gumweed
GUTSAR	<i>Gutierrezia sarothrae</i>	Broom snakeweed
HABHYP	<i>Habenaria hyperborea</i>	Northern green bog-orchid
HABSAC	<i>Habenaria saccata</i>	Slender bog-orchid
HABUNA	<i>Habenaria unalascentis</i>	Alaska rein-orchid
HACMIC	<i>Hackelia micrantha</i>	Blue stickseed
HAPLAN	<i>Haplopappus lanceolatus</i>	Lance-leaf goldenweed
HAPUNI	<i>Haplopappus uniflorus</i>	One-flowered goldenweed
HEDBOR	<i>Hedysarum boreale</i>	Northern hedysarum
HEDSUL	<i>Hedysarum sulphurescens</i>	Yellow hedysarum
HELUNI	<i>Helianthella uniflora</i>	Rocky Mountain helianthella
HELMAX	<i>Helianthus maximiliani</i>	Maximilian's sunflower
HELNUT	<i>Helianthus nuttallii</i>	Nuttall's sunflower
HELRIE	<i>Helianthus rigidus</i>	Showy sunflower
HELHOO	<i>Helictotrichon hookeri</i>	Spike oat
HERSPH	<i>Heracleum sphondylium</i>	Cow-parsnip
HESMAT	<i>Hesperis matronalis</i>	Dame's rocket
HETVIL	<i>Heterotheca villosa</i>	Hairy goldenaster
HEUCYL	<i>Heuchera cylindrica</i>	Roundleaf alumroot
HEUGRO	<i>Heuchera grossulariifolia</i>	Gooseberry-leaved alumroot
HIEALE	<i>Hieracium albertinum</i>	Western hawkweed
HIEALB	<i>Hieracium albiflorum</i>	White-flowered hawkweed
HIEUMB	<i>Hieracium umbellatum</i>	Narrow-leaved hawkweed
HORBRA	<i>Hordeum brachyantherum</i>	Meadow barley
HORJUB	<i>Hordeum jubatum</i>	Foxtail barley
HYMACA	<i>Hymenoxys acaulis</i>	Stemless hymenoxys
HYMRIC	<i>Hymenoxys richardsonii</i>	Richardson's hymenoxys
IRIMIS	<i>Iris missouriensis</i>	Rocky mountain iris
JUNBAL	<i>Juncus balticus</i>	Baltic rush
JUNBUF	<i>Juncus bufonius</i>	Toad rush
JUNEFF	<i>Juncus effusus</i>	Soft rush
JUNENS	<i>Juncus ensifolius</i>	Dagger-leaf rush
JUNLON	<i>Juncus longistylis</i>	Long-styled rush
JUNNOD	<i>Juncus nodosus</i>	Tuberous rush
JUNTEN	<i>Juncus tenuis</i>	Slender rush

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JUNTRA	<i>Juncus tracyi</i>	Tracy's rush
JUNCOM	<i>Juniperus communis</i>	Common juniper
JUNHOR	<i>Juniperus horizontalis</i>	Creeping juniper
JUNSCO	<i>Juniperus scopulorum</i>	Rocky mountain juniper
KOEMAC	<i>Koeleria macrantha</i>	Prairie junegrass
LAPMYO	<i>Lappula myosotis</i>	Bristly stickseed
LATOCH	<i>Lathyrus ochroleucus</i>	Cream-flowered peavine
LESLUD	<i>Lesquerella ludoviciana</i>	Bladderpod
LIAPUN	<i>Liatris punctata</i>	Dotted blazing-star
LIGTEN	<i>Ligusticum tenuifolium</i>	Slender-leaved licorice-root
LILPHI	<i>Lilium philadelphicum</i>	Red lily
LINPER	<i>Linum lewisii</i>	Wild blue flax
LITRUD	<i>Lithospermum ruderales</i>	Western gromwell
LOMCOU	<i>Lomatium cous</i>	Cous biscuit-root
LOMDIS	<i>Lomatium dissectum</i>	Fern-leaved lomatium
LOMMAC	<i>Lomatium macrocarpum</i>	Large-fruit lomatium
LOMTRI	<i>Lomatium triternatum</i>	Nine-leaf lomatium
LUPARG	<i>Lupinus argenteus</i>	Silvery lupine
LUPSER	<i>Lupinus sericeus</i>	Silky lupine
LUPWYE	<i>Lupinus wyethii</i>	Wyeth's lupine
LUZPAR	<i>Luzula parviflora</i>	Small-flowered woodrush
LYNDRU	<i>Lynchnis drummondii</i>	Drummond campion
LYSCIL	<i>Lysimachia ciliata</i>	Fringed loosestrife
MAHREP	<i>Mahonia repens</i>	Creeping oregon grape
MEDLUP	<i>Medicago lupulina</i>	Black medic
MEDSAT	<i>Medicago sativa</i>	Alfalfa
MELLIN	<i>Melampyrum lineare</i>	Narrow-leaved cow-wheat
MELSPE	<i>Melica spectabilis</i>	Showy oniongrass
MELOFF	<i>Melilotus officinalis</i>	Yellow sweet-clover
MENARV	<i>Mentha arvensis</i>	Field mint
MERVIR	<i>Mertensia viridis</i>	Green bluebells
MIMGUT	<i>Mimulus guttatus</i>	Common monkey flower
MONFIS	<i>Monarda fistulosa</i>	Horsemint
MUHCUS	<i>Muhlenbergia cuspidata</i>	Plains muhly
MUHFIL	<i>Muhlenbergia filiformis</i>	Slender muhly
MUHRIC	<i>Muhlenbergia richardsonii</i>	Mat muhly
OENCAE	<i>Oenothera caespitosa</i>	Rock-rose
OROCOR	<i>Orobancha corymbosa</i>	Flat-topped broomrape
OROFAS	<i>Orobancha fasciculata</i>	Clustered broomrape
ORTSEC	<i>Orthilia secunda</i>	One-sided wintergreen
ORTLUT	<i>Orthocarpus luteus</i>	Yellow owl-clover
OSMCHI	<i>Osmorhiza chilensis</i>	Mountain sweet-cicely
OSMOCC	<i>Osmorhiza occidentalis</i>	Western sweet-cicely
OXYVIS	<i>Oxytropis viscidula</i>	Sticky crazyweed
OXYDEF	<i>Oxytropis deflexa</i>	Pendent-pod crazyweed
OXYLAG	<i>Oxytropis lagopus</i>	Rabbit-foot crazyweed
OXYMON	<i>Oxytropis monticola</i>	Slender crazyweed
OXYSER	<i>Oxytropis sericea</i>	Silky crazyweed

6 letter code	SCIENTIFIC NAME	COMMON NAME
OXYSP	<i>Oxytropis splendens</i>	Showy crazyweed
PARPAL	<i>Parnassia palustris</i>	Northern grass-of-parnassus
PEDBRA	<i>Pedicularis bracteosa</i>	Bracted lousewort
PEDCON	<i>Pedicularis contorta</i>	Coiled-beak lousewort
PEDGRO	<i>Pedicularis groenlandica</i>	Elephant's head
PENCON	<i>Penstemon confertus</i>	Yellow penstemon
PENERI	<i>Penstemon eriantherus</i>	Fuzzytongue penstemon
PENNIT	<i>Penstemon nitidus</i>	Shining penstemon
PENFLO	<i>Pentaphylloides floribunda</i>	Shrubby cinquefoil
PERGAI	<i>Perideridia gairdneri</i>	Gairdner's yampa
PHAHAS	<i>Phacelia hastata</i>	Silverleaf phacelia
PHASER	<i>Phacelia sericea</i>	Silky phacelia
PHAARU	<i>Phalaris arundinacea</i>	Reed canarygrass
PHLPRA	<i>Phleum pratense</i>	Common timothy
PHLALB	<i>Phlox albomarginata</i>	White-margined phlox
PHLALY	<i>Phlox alyssifolia</i>	Alyssum-leaved phlox
PHLHOO	<i>Phlox hoodii</i>	Hood's phlox
PHYDID	<i>Physaria didymocarpa</i>	Common twinpod
PICENG	<i>Picea engelmannii</i>	Engelman spruce
PINCON	<i>Pinus contorta</i>	Lodgepole pine
PINFLE	<i>Pinus flexilis</i>	Limber pine
PLACAN	<i>Plantago canescens</i>	Hoary plantain
PLAELO	<i>Plantago elongata</i>	Slender plantain
PLAERI	<i>Plantago eriopoda</i>	Saline plantain
PLALAN	<i>Plantago lanceolata</i>	Buckhorn plantain
PLAMAJ	<i>Plantago major</i>	English plantain
PLATWE	<i>Plantago tweedyi</i>	Tweedy's plantain
POACOM	<i>Poa compressa</i>	Canada bluegrass
POANER	<i>Poa nervosa</i>	Wheeler's bluegrass
POAPAL	<i>Poa palustris</i>	Fowl bluegrass
POAPRA	<i>Poa pratensis</i>	Kentucky bluegrass
POATRI	<i>Poa trivialis</i>	Roughstalk bluegrass
POLOCC	<i>Polemonium occidentale</i>	Western polemonium
POLPUL	<i>Polemonium pulcherrimum</i>	Skunk-leaved polemonium
POLBIS	<i>Polygonum bistortoides</i>	American bistort
POPANG	<i>Populus angustifolia</i>	Narrowleaf cottonwood
POPDEL	<i>Populus deltoides</i>	Eastern cottonwood
POPTRE	<i>Populus tremuloides</i>	Quaking aspen
POPTRI	<i>Populus trichocarpa</i>	Black cottonwood
POTNAT	<i>Potamogeton natans</i>	Floating-leaved pondweed
POTANS	<i>Potentilla anserina</i>	Common silverweed
POTARG	<i>Potentilla arguta</i>	Tall cinquefoil
POTGLA	<i>Potentilla glandulosa</i>	Sticky cinquefoil
POTGRA	<i>Potentilla gracilis</i>	Soft cinquefoil
POTHIP	<i>Potentilla hippiana</i>	Woolly cinquefoil
POTPEN	<i>Potentilla pensylvanica</i>	Prairie cinquefoil
PRUVUL	<i>Prunella vulgaris</i>	Self-heal
PRUVIR	<i>Prunus virginiana</i>	Common chokecherry

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PSEMEN	<i>Pseudotsuga menziesii</i>	Douglas-fir
PTEAND	<i>Pterospora andromedea</i>	Woodland pinedrops
PYRASA	<i>Pyrola asarifolia</i>	Pink wintergreen
RANMIC	<i>Ranunculus macounii</i>	Macoun's buttercup
RATCOL	<i>Ratibiba columnifera</i>	Prairie coneflower
RHUTRI	<i>Rhus trilobata</i>	Sumac
RIBCEB	<i>Ribes cereum</i>	Squaw currant
RIBVIS	<i>Ribes viscosum</i>	Sticky Current, gooseberry
ROSSAY	<i>Rosa sayi</i>	Prickly rose
ROSWOO	<i>Rosa woodsii</i>	Woods rose
RUBIDA	<i>Rubus idaeus</i>	Red raspberry
RUBPAR	<i>Rubus parviflorus</i>	Thimbleberry
RUDLAC	<i>Rudbeckia laciniata</i>	Tall coneflower
RUMSAL	<i>Rumex salicifolius</i>	Willow dock
SALBEB	<i>Salix bebbiana</i>	Bebb willow
SALBOO	<i>Salix boothii</i>	Booth willow
SALCAN	<i>Salix candida</i>	Hoary willow
SALEXI	<i>Salix exigua</i>	Sandbar willow
SALLUT	<i>Salix lutea</i>	Watson willow
SALSCO	<i>Salix scouleriana</i>	Scouler's willow
SANMAR	<i>Sanicula marilandica</i>	Black snake-root
SAXINT	<i>Saxifrage integrifolia</i>	Swamp saxifrage
SCIAME	<i>Scirpus americanus</i>	American bulrush
SCIMIC	<i>Scirpus microcarpus</i>	Small-flowered bulrush
SEDLAN	<i>Sedum lanceolatum</i>	Lanceleaf stonecrop
SEDSTE	<i>Sedum stenopetalum</i>	Wormleaf stonecrop
SELDEN	<i>Selaginella densa</i>	Compact selaginella
SENCAN	<i>Senecio canus</i>	Woolly groundsel
SENCRO	<i>Senecio crassulus</i>	Thick-leaved groundsel
SENCYN	<i>Senecio cymbalarioides</i>	Few-leaved groundsel
SENINT	<i>Senecio integerrimus</i>	Western groundsel
SENPAT	<i>Senecio pauperculus</i>	Balsam groundsel
SENPSE	<i>Senecio pseudoreus</i>	Streambank groundsel
SENTRI	<i>Senecio triangularis</i>	Arrowleaf groundsel
SHECAN	<i>Shepherdia canadensis</i>	Canada buffaloberry
SILVUL	<i>Silene vulgaris</i>	Bladder campion
SISMON	<i>Sisyrinchium montanum</i>	Blue-eyed grass
SMIRAC	<i>Smilacina racemosa</i>	False spikenard
SMISTE	<i>Smilacina stellata</i>	Starry solomon-plume
SOLCAN	<i>Solidago canadensis</i>	Canada goldenrod
SOLGIG	<i>Solidago gigantea</i>	Late goldenrod
SOLMIS	<i>Solidago missouriensis</i>	Missouri goldenrod
SOLOCC	<i>Solidago occidentalis</i>	Western goldenrod
SOLSPA	<i>Solidago spathulata</i>	Dune goldenrod
SONARV	<i>Sonchus arvensis</i>	Field milk-thistle
SPAPEC	<i>Spartina pectinata</i>	Prairie cordgrass
SPIROM	<i>Spiranthes romanoffiana</i>	Hooded ladies-tresses
SPIBET	<i>Spirea betulifolia</i>	Shiny-leaf spiraea

6 letter code	SCIENTIFIC NAME	COMMON NAME
STAPAL	<i>Stachys palustris</i>	Swamp hedge-nettle
STECAL	<i>Stellaria calycantha</i>	Northern starwort
STICOM	<i>Stipa comata</i>	Needle-and-thread
STIOCC	<i>Stipa occidentalis</i>	Western needlegrass
STIRIC	<i>Stipa richardsonii</i>	Richardson's needlegrass
STIVIR	<i>Stipa viridula</i>	Green needlegrass
SYMALB	<i>Symphoricarpos albus</i>	Common snowberry
TANVUL	<i>Tanacetum vulgare</i>	Common tansy
TAROFF	<i>Taraxacum officinale</i>	Common dandelion
THAOCC	<i>Thalictrum occidentale</i>	Western meadowrue
THAVEN	<i>Thalictrum venulosum</i>	Veiny meadowrue
THEINT	<i>Thelypodium integrifolium</i>	Entire-leaved thelypody
THEMON	<i>Thermopsis montana</i>	Mountain thermopsis
THERHO	<i>Thermopsis rhombifolia</i>	Round-leaved thermopsis
THLARV	<i>Thlasi arvense</i>	Field pennycress
TOWHOO	<i>Townsendia hookeri</i>	Hooker's Easter daisy
TOWPAR	<i>Townsendia parryi</i>	Parry's daisy
TRADUB	<i>Tragopogon dubius</i>	Goat's beard, salsify
TRIHVB	<i>Trifolium hybridum</i>	Alsike clover
TRILON	<i>Trifolium longipes</i>	Long-stalked clover
TRIPRA	<i>Trifolium pratense</i>	Red clover
TRIMAR	<i>Triglochin maritimum</i>	Seaside arrow-grass
TRIOVA	<i>Trillium ovatum</i>	White trillium
TRICAN	<i>Trisetum canescens</i>	Tall trisetum
TRICER	<i>Trisetum cernuum</i>	Nodding trisetum
TRISPI	<i>Trisetum spicatum</i>	Spike trisetum
TYPLAT	<i>Typha latifolia</i>	Common cattail
URTDIO	<i>Urtica dioica</i>	Stinging nettle
VALDIO	<i>Valeriana dioica</i>	Northern valerian
VALEDU	<i>Valeriana edulis</i>	Edible valerian
VALSIT	<i>Valeriana sitchensis</i>	Sitka valerian
VERVIR	<i>Veratrum viride</i>	Green false hellebore
VERAME	<i>Veronica americana</i>	American speedwell
VERPER	<i>Veronica persica</i>	Persain speedwell
VICAME	<i>Vicia americana</i>	American vetch
VIOADU	<i>Viola adunca</i>	Early blue violet
VIOCAN	<i>Viola canadensis</i>	Canada violet
VIONUT	<i>Viola nuttallii</i>	Nuttall violet
VIOORB	<i>Viola orbiculata</i>	Round-leaved violet
ZIGELE	<i>Zigadenus elegans</i>	Glaucous camas
ZIGVEN	<i>Zigadenus venenosus</i>	Meadow death-camas
ZIZAPT	<i>Zizia aptera</i>	Heart-leaved alexanders

NATURAL HISTORY OF LIMBER PINE

Limber pine is widely distributed throughout western North America (Figure 11). The growth form of this long-lived pine varies greatly throughout its distribution, resembling western white pine in southern geographic areas and whitebark pine throughout its northern distribution. Isolated populations are found as far south as Southern California, Arizona, and New Mexico. Its northern range includes most of the Rocky Mountains into Alberta and British Columbia (Steele 1990). Limber pine grows at reported elevations ranging from 870 m in North Dakota (Potter and Green 1964) to 3810 m in Colorado (Douglas and Douglas 1955). The largest contiguous population is found along the eastern front of the Rocky Mountains from the Wind River range in Wyoming to Jasper National Park in Alberta (Steele 1990).

In its range north of the 40th parallel, limber pine is typically found at the lower tree line and on dry, windswept sites. In lower elevations, it grows in semi-forested areas characterized by a continental climate with low precipitation, low humidity, and wide annual and diurnal temperature ranges (Steele 1990). In these harsh growing conditions, this species, with its high drought and wind tolerance, is generally considered a 'climax' species (Fischer and Clayton 1983), although limber pine can be succeeded by less drought tolerant species in some xeric sites (Patten 1963). In these dry areas, the presence of limber pine may create moister conditions (through shade, greater snow accumulation, and/or reduction of wind) conducive for mesic species, such as spruce (*Picea spp.*) (Shankman and Daly 1988) and Douglas fir (Butler 1986). In mesic sites, limber pine is a seral species that is successional replaced by Douglas-fir, Engelmann spruce (*Picea engelmannii*), and less frequently by lodgepole pine (*Pinus contorta*) (Butler 1986). Other associated tree species include Rocky Mountain juniper (*Juniperus scopulorum*) and ponderosa pine (*Pinus ponderosa*) in xeric sites, and subalpine fir (*Abies lasiocarpa*), whitebark pine, and white spruce (*Picea glauca*) in mesic sites (Steele 1990).

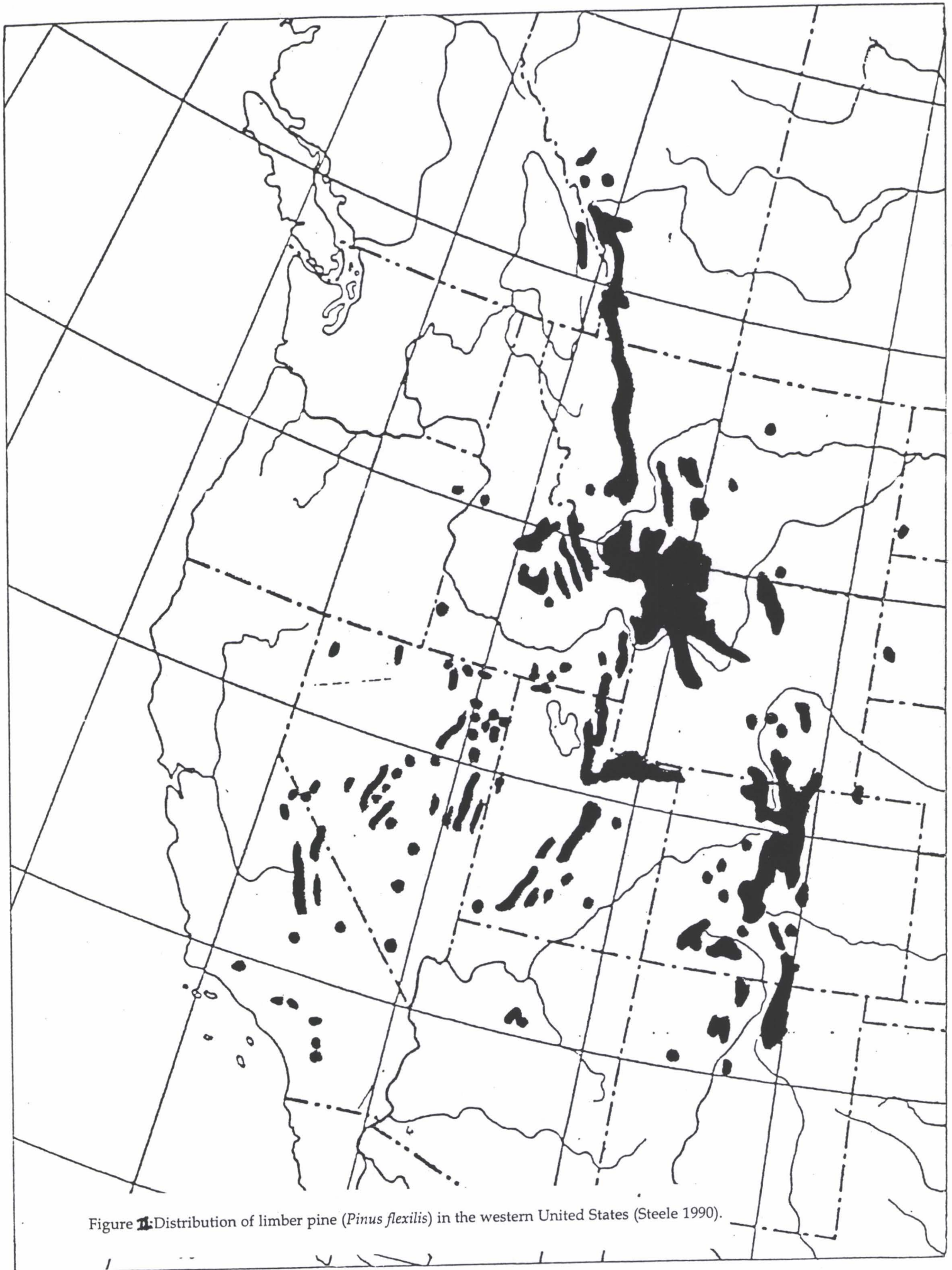


Figure 1: Distribution of limber pine (*Pinus flexilis*) in the western United States (Steele 1990).

DESCRIPTION OF LIMBER PINE COMMUNITIES

Along the Rocky Mountain Front, limber pine habitats are the only dominant conifer habitats. Currently, these communities comprise approximately 15% of the land cover in the 10 km wide ecotone between the Rocky Mountain forests and the Great Plains grasslands. Limber pine communities are generally found along the ridges and on windswept slopes; occasionally some stands are found along riparian corridors. These stands have relatively low canopy cover as forests (rarely exceeding 60%), but high canopy cover as savanna habitats (rarely occurring below 15% canopy cover). Tree height in these communities averages around 4 m and seldom exceeds 8 m. The majority of trees are pole trees, most likely related to the relatively recent expansion of this species into the fescue grasslands. Understory characteristics appear to be strongly related to macrotopographic characteristics and stand age (Ayers Baumeister *unpubl. data*). The Front has almost double the yearly precipitation to the north as the south and this is reflected in the quantity and composition of understory species. Additionally, stand age appears to play a strong role in determining community composition—as stands age, canopy cover increases, light decreases, temperatures cool, soil moisture increases and the depth of the A and O soil horizon increase (Ayers Baumeister *unpubl. data*). Any or all of these factors may play be determinants of community composition (Tupas and Sajise 1977, Caprio et al. 1981, Belsky and Canham 1994).

To characterize limber pine communities within the Birch Creek-Teton River study area, 52 plots were sampled at three locations: Theodore Roosevelt Memorial Ranch, Blackleaf Wildlife Management Area and Pine Butte Swamp Preserve. Modified ecodata plots were performed at these sites. A species list compiled from Hurlburt (1996), Lesica and Hanna (1996) and unpublished data is presented in Table 2. A brief summary of community characteristics is presented in Figure 12. Amelioration of abiotic conditions by limber pine communities is found in Figures 13-14.

Table 2. Species List for Limber Pine Communities (Adapted from Hurlburt 1996, Lesica and Hanna 1996, *unpubl. data*).

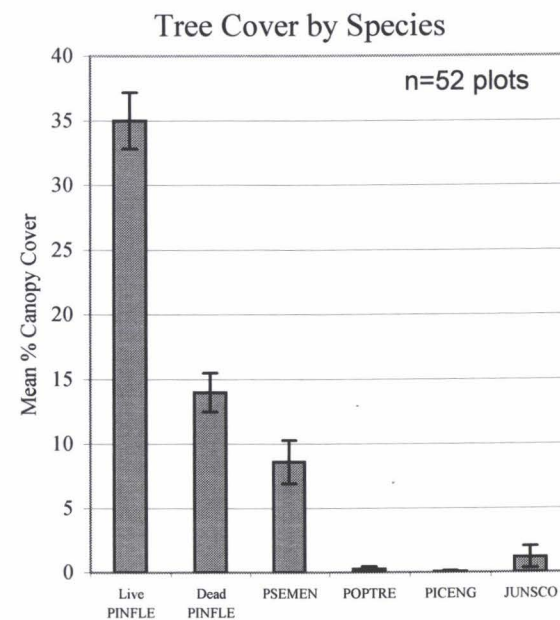
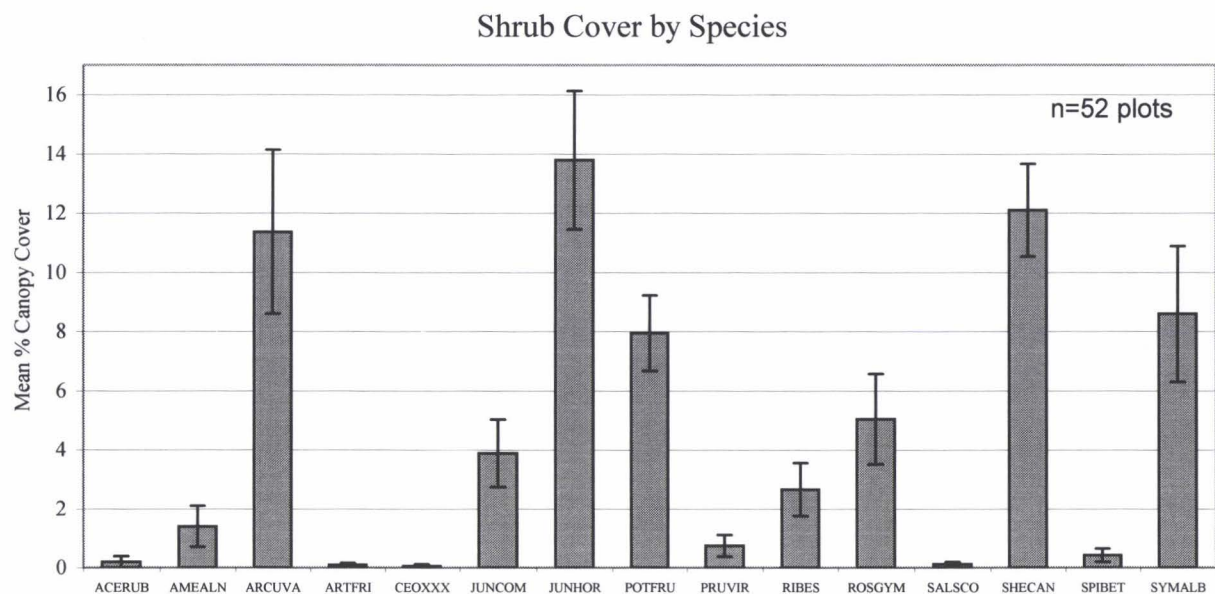
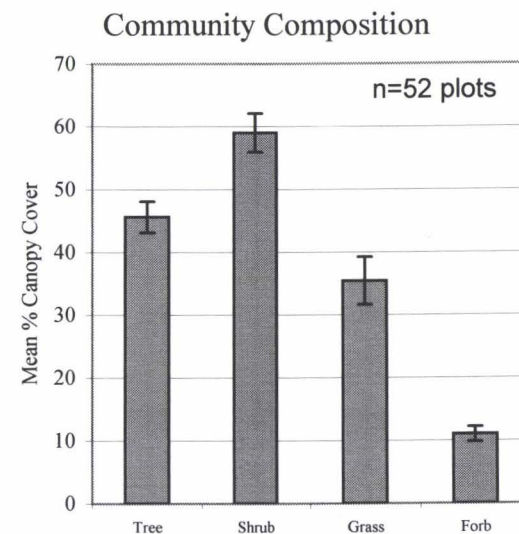
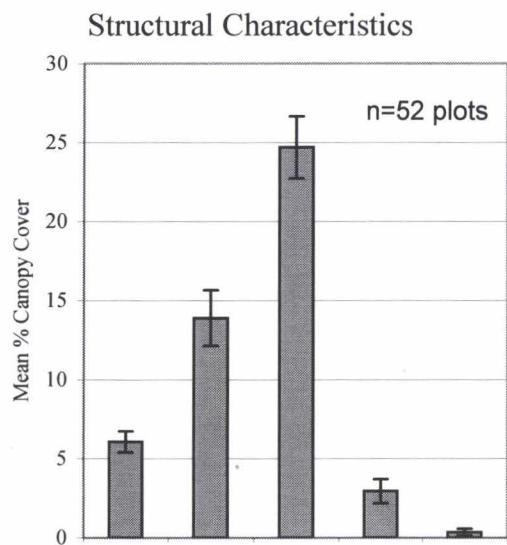
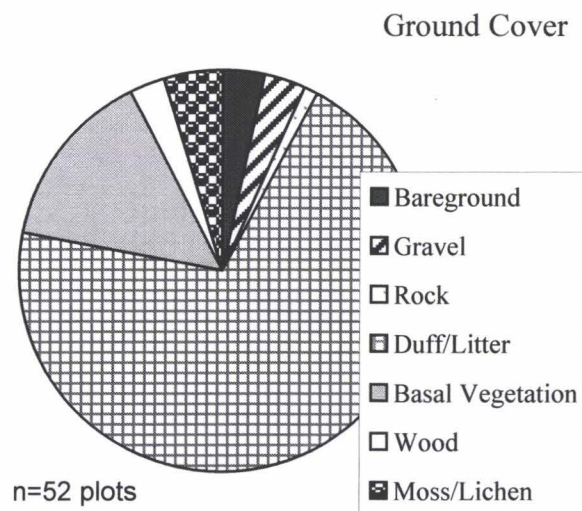
6 letter code	SCIENTIFIC NAME	COMMON NAME	6 letter code	SCIENTIFIC NAME	COMMON NAME
ACHMIL	<i>Achillea millefolium</i>	Yarrow	BUPAME	<i>Bupleurum americanum</i>	American thorough-wax
AGOGLA	<i>Agoseris glauca</i>	False dandelion	CALPUR	<i>Calamagrostis purpurascens</i>	Purple reedgrass
AGRCAN	<i>Agropyron caninum</i>	Awne'd wheatgrass	CALRUB	<i>Calamagrostis rubescens</i>	Pinegrass
AGRDAS	<i>Agropyron dasytachyum</i>	Thick-spiked wheatgrass	CAMROT	<i>Campanula rotundifolia</i>	Harebell
AGRSCA	<i>Agrostis scabra</i>	Rough bentgrass-ticklegrass	CARFIL	<i>Carex filifolia</i>	Thread-leaved sedge
ALLCER	<i>Allium cernuum</i>	Nodding onion	CAROB	<i>Carex obtusata</i>	Blunt sedge
ALYALY	<i>Alyssum alyssoides</i>	Pale alyssum	CARRAY	<i>Carex raynoldsii</i>	Raynolds' sedge
AMEALN	<i>Amelanchier alnifolia</i>	Serviceberry	CARROI	<i>Carex rossii</i>	Ross sedge
ANAMAR	<i>Anaphalis margaritacea</i>	Pearly everlasting	CASMIN	<i>Castilleja minata</i>	Scarlet paintbrush
ANEMUL	<i>Anemone multifida</i>	Cliff anemone	CERARV	<i>Cerastium arvense</i>	Field chickweed
ANENUT	<i>Anemone nuttalliana</i>	Pasque flower	CIRUND	<i>Cirsium undulatum</i>	Wavy-leaved thistle
ANTANA	<i>Antennaria anaphaloides</i>	Tall pussytoes	CLALAN	<i>Claytonia lanceolata</i>	Spring beauty
ANTNEG	<i>Antennaria neglecta</i>	Field pussytoes	CLECOL	<i>Clematis columbiana</i>	Columbia clematis
ANTROS	<i>Antennaria rosea</i>	Rose pussytoes	CLEHIR	<i>Clematis hirsutissima</i>	Vaseflower clematis
APOAND	<i>Apocynum androsaemifolium</i>	Dogbane	COLPAR	<i>Collinsia parviflora</i>	Blue-eyed mary
ARASPA	<i>Arabis hirsuta</i>	Hairy rockcress	COLLIN	<i>Collomia linearis</i>	Narrow-leaf collomia
ARCUVA	<i>Arctostaphylos uva-ursi</i>	Kinnikinnick	COMUMB	<i>Comandra umbellata</i>	Bastard toad-flax
ARECON	<i>Arenaria congesta</i>	Ballhead sandwort	CREACU	<i>Crepis acuminata</i>	Tapertip hawksbeard
ARNSOR	<i>Arnica sororia</i>	Twin arnica	CRYSPI	<i>Cryptantha spiculifera</i>	Bristly cryptantha
ARTCAM	<i>Artemisia campestris</i>	Pacific sagewort	CYPMON	<i>Cypripedium montanum</i>	Mountain lady's-slipper
ARTDRA	<i>Artemisia dracunculus</i>	Tarragon	DALCAN	<i>Dalea candida</i>	White prairie-clover
ARTFRI	<i>Artemisia frigida</i>	Fringed sage	DALPUR	<i>Dalea purpurea</i>	Purple prairie clover
ARTLUD	<i>Artemisia ludoviciana</i>	Prairie sagewort	DANINT	<i>Danthonia intermedia</i>	Timber oatgrass
ASTFAL	<i>Aster falcatus</i>	Little gray aster	DANUNI	<i>Danthonia unispicata</i>	Onespike oatgrass
ASTCRA	<i>Astragalus crassica'pus</i>	Groundplum milkvetch	DELBIC	<i>Delphinium bicolor</i>	Larkspur
ASTDRU	<i>Astragalus drummondii</i>	Drummond's milkvetch	DODCON	<i>Dodecatheon conjugens</i>	Slimpod shooting star
ASTGIL	<i>Astragalus gilviflorus</i>	Plains orophaca	DOUMON	<i>Douglasia montana</i>	Mountain douglasia
ASTVEX	<i>Astragalus vexilliflexus</i>	Bentflowered milkvetch	ELYSPI	<i>Elymus spicata</i>	Bluebunch wheatgrass
BALINC	<i>Balsamorhiza incana</i>	Hoary balsamroot	ERICA	<i>Erigeron caespitosus</i>	Tufted fleabane
BALSAG	<i>Balsamorhiza sagittata</i>	Arrowleaf balsamroot	ERICOM	<i>Erigeron compositus</i>	Cut-leaved daisy
BESWYO	<i>Besseyia wyomingensis</i>	Wyoming kittentail	ERIOCH	<i>Erigeron ochroleucus</i>	Buff fleabane
BROCAR	<i>Bromus carinatus</i>	Mountain brome	ERISPE	<i>Erigeron speciosus</i>	Showy fleabane
BROINE	<i>Bromus inermis</i>	Smooth brome	ERIFLA	<i>Eriogonum flavum</i>	Yellow buckwheat

6 letter code	SCIENTIFIC NAME	COMMON NAME
ERIHOW	<i>Eritrichium howardii</i>	Alpine forget-me-not
ERYREP	<i>Erysimum repandum</i>	Spreading wallflower
ERYGRA	<i>Erythronium grandiflorum</i>	Glacier-lily
EUPESU	<i>Euphorbia esula</i>	Leafy spurge
FESIDA	<i>Festuca idahoensis</i>	Idaho fescue
FESSCA	<i>Festuca scabrella</i>	Rough fescue
FRAVES	<i>Fragaria vesca</i>	Woods strawberry
FRAVIR	<i>Fragaria virginiana</i>	Virginia strawberry
FRIPUD	<i>Fritillaria pudica</i>	Yellow bells
GAIARI	<i>Gaillardia aristata</i>	Blanket-flower
GALBOR	<i>Galium boreale</i>	Northern bedstraw
GAUCOC	<i>Gaura coccinea</i>	Scarlet gaura
GENAFF	<i>Gentiana affinis</i>	Pleated gentian
GENAMA	<i>Gentianella amarella</i>	Northern gentian
GERVIS	<i>Geranium viscosissimum</i>	Sticky geranium
GEUTRI	<i>Geum triflorum</i>	Prairie smoke
GRISQU	<i>Grindelia squarrosa</i>	Curlycup gumweed
GUTSAR	<i>Gutierrezia sarothrae</i>	Broom snakeweed
HEDBOR	<i>Hedysarum boreale</i>	Northern hedysarum
HEDSUL	<i>Hedysarum sulphurescens</i>	Yellow hedysarum
HELHOO	<i>Helictotrichon hookeri</i>	Spike oat
HETVIL	<i>Heterotheca villosa</i>	Hairy goldenaster
HEUCYL	<i>Heuchera cylindrica</i>	Roundleaf alumroot
HIEALE	<i>Hieracium albertinum</i>	Western hawkweed
HYMACA	<i>Hymenoxys acaulis</i>	Stemless hymenoxys
HYMRIC	<i>Hymenoxys richardsonii</i>	Richardson's hymenoxys
IRIMIS	<i>Iris missouriensis</i>	Rocky mountain iris
JUNCOM	<i>Juniperus communis</i>	Common juniper
JUNHOR	<i>Juniperus horizontalis</i>	Creeping juniper
JUNSCO	<i>Juniperus scopulorum</i>	Rocky mountain juniper
KOEMAC	<i>Koeleria macrantha</i>	Prairie junegrass
LIAPUN	<i>Liatris punctata</i>	Dotted blazing-star
LIGTEN	<i>Ligusticum tenuifolium</i>	Slender-leaved licorice-root
LINPER	<i>Linum lewisii</i>	Wild blue flax
LITRUD	<i>Lithospermum rudemale</i>	Western gromwell
LOMCOU	<i>Lomatium cous</i>	Cous biscuit-root

6 letter code	SCIENTIFIC NAME	COMMON NAME
LOMMAC	<i>Lomatium macrocarpum</i>	Large-fruit lomatium
LOMTRI	<i>Lomatium triternatum</i>	Nine-leaf lomatium
LUPARG	<i>Lupinus argenteus</i>	Silvery lupine
LUPSER	<i>Lupinus sericeus</i>	Silky lupine
LUPWYE	<i>Lupinus wyethii</i>	Wyeth's lupine
MAHREP	<i>Mahonia repens</i>	Creeping oregongrape
MELOFF	<i>Melilotus officinalis</i>	Yellow sweet-clover
MENARV	<i>Mentha arvensis</i>	Field mint
MERVIR	<i>Mertensia viridis</i>	Green bluebells
MONFIS	<i>Monarda fistulosa</i>	Horsemint
OENCAE	<i>Oenothera caespitosa</i>	Rock-rose
OROFAS	<i>Orobanche fasciculata</i>	Clustered broomrape
ORTLUT	<i>Orthocarpus luteus</i>	Yellow owl-clover
OSMCHI	<i>Osmorhiza chilensis</i>	Mountain sweet-cicely
OSMOCC	<i>Osmorhiza occidentalis</i>	Western sweet-cicely
OXYVIS	<i>Oxytropis visicida</i>	Sticky crazyweed
OXYLAG	<i>Oxytropis lagopus</i>	Rabbit-foot crazyweed
OXYMON	<i>Oxytropis monticola</i>	Slender crazyweed
OXYSER	<i>Oxytropis sericea</i>	Silky crazyweed
PEDCON	<i>Pedicularis contorta</i>	Coiled-beak lousewort
PENCON	<i>Penstemon confertus</i>	Yellow penstemon
PENERI	<i>Penstemon eriantherus</i>	Fuzzytongue penstemon
PENNIT	<i>Penstemon nitidus</i>	Shining penstemon
PENFLO	<i>Pentaphylloides floribunda</i>	Shrubby cinquefoil
PHAHAS	<i>Phacelia hastata</i>	Silverleaf phacelia
PHLPRA	<i>Phleum pratense</i>	Common timothy
PHLALY	<i>Phlox alyssifolia</i>	Alyssum-leaved phlox
PHLHOO	<i>Phlox hoodii</i>	Hood's phlox
PICENG	<i>Picea engelmannii</i>	Engelman spruce
PINCON	<i>Pinus contorta</i>	Lodgepole pine
PINFLE	<i>Pinus flexilis</i>	Limber pine
PLACAN	<i>Plantago canescens</i>	Hoary plantain
POACOM	<i>Poa compressa</i>	Canada bluegrass
POAPRA	<i>Poa pratensis</i>	Kentucky bluegrass
POLPUL	<i>Polemonium pulcherrimum</i>	Skunk-leaved polemonium
POLBIS	<i>Polygonum bistortoides</i>	American bistort

6 letter code	SCIENTIFIC NAME	COMMON NAME
POPTRE	<i>Populus tremuloides</i>	Quaking aspen
POTARG	<i>Potentilla arguta</i>	Tall cinquefoil
POTGLA	<i>Potentilla glandulosa</i>	Sticky cinquefoil
POTGRA	<i>Potentilla gracilis</i>	Soft cinquefoil
POTHIP	<i>Potentilla hippiana</i>	Woolly cinquefoil
POTPEN	<i>Potentilla pensylvanica</i>	Prairie cinquefoil
PRUVIR	<i>Prunus virginiana</i>	Common chokecherry
PSEMEN	<i>Pseudotsuga menziesii</i>	Douglas-fir
PTEAND	<i>Pterospora andromedea</i>	Woodland pinedrops
RANMIC	<i>Ranunculus macounii</i>	Macoun's buttercup
RHUTRI	<i>Rhus trilobata</i>	Sumac
RIB CER	<i>Ribes cereum</i>	Squaw currant
RIBVIS	<i>Ribes viscosum</i>	Sticky Current, gooseberry
ROSSAY	<i>Rosa sayi</i>	Prickly rose
ROSWOO	<i>Rosa woodsii</i>	Woods rose
RUBPAR	<i>Rubus parviflorus</i>	Thimbleberry
RUDLAC	<i>Rudbeckia laciniata</i>	Tall coneflower
SEDLAN	<i>Sedum lanceolatum</i>	Lanceleaf stonecrop
SEDSTE	<i>Sedum stenopetalum</i>	Wormleaf stonecrop
SELDEN	<i>Selaginella densa</i>	Compact selaginella
SENINT	<i>Senecio integerrimus</i>	Western groundsel

6 letter code	SCIENTIFIC NAME	COMMON NAME
SHECAN	<i>Shepherdia canadensis</i>	Canada buffaloberry
SISMON	<i>Sisyrinchium montanum</i>	Blue-eyed grass
SMISTE	<i>Smilacina stellata</i>	Starry solomon-plume
SOLMIS	<i>Solidago missouriensis</i>	Missouri goldenrod
SPIBET	<i>Spirea betulifolia</i>	Shiny-leaf spiraea
STICOM	<i>Stipa comata</i>	Needle-and-thread
STIOCC	<i>Stipa occidentalis</i>	Western needlegrass
SYMALB	<i>Symphoricarpos albus</i>	Common snowberry
TAROFF	<i>Taraxacum officinale</i>	Common dandelion
THAOCC	<i>Thalictrum occidentale</i>	Western meadowrue
THLARV	<i>Thlasi arvense</i>	Field pennycress
TOWHOO	<i>Townsendia hookeri</i>	Hooker's Easter daisy
TOWPAR	<i>Townsendia parryi</i>	Parry's daisy
TRADUB	<i>Tragopogon dubius</i>	Goat's beard, salsify
TRISPI	<i>Trisetum spicatum</i>	Spike trisetum
VALEDU	<i>Valeriana edulis</i>	Edible valerian
VICAME	<i>Vicia americana</i>	American vetch
VIONUT	<i>Viola nuttallii</i>	Nuttall violet
ZIGELE	<i>Zigadenus elegans</i>	Glaucous camas
ZIGVEN	<i>Zigadenus venenosus</i>	Meadow death-camas



WIND VELOCITY

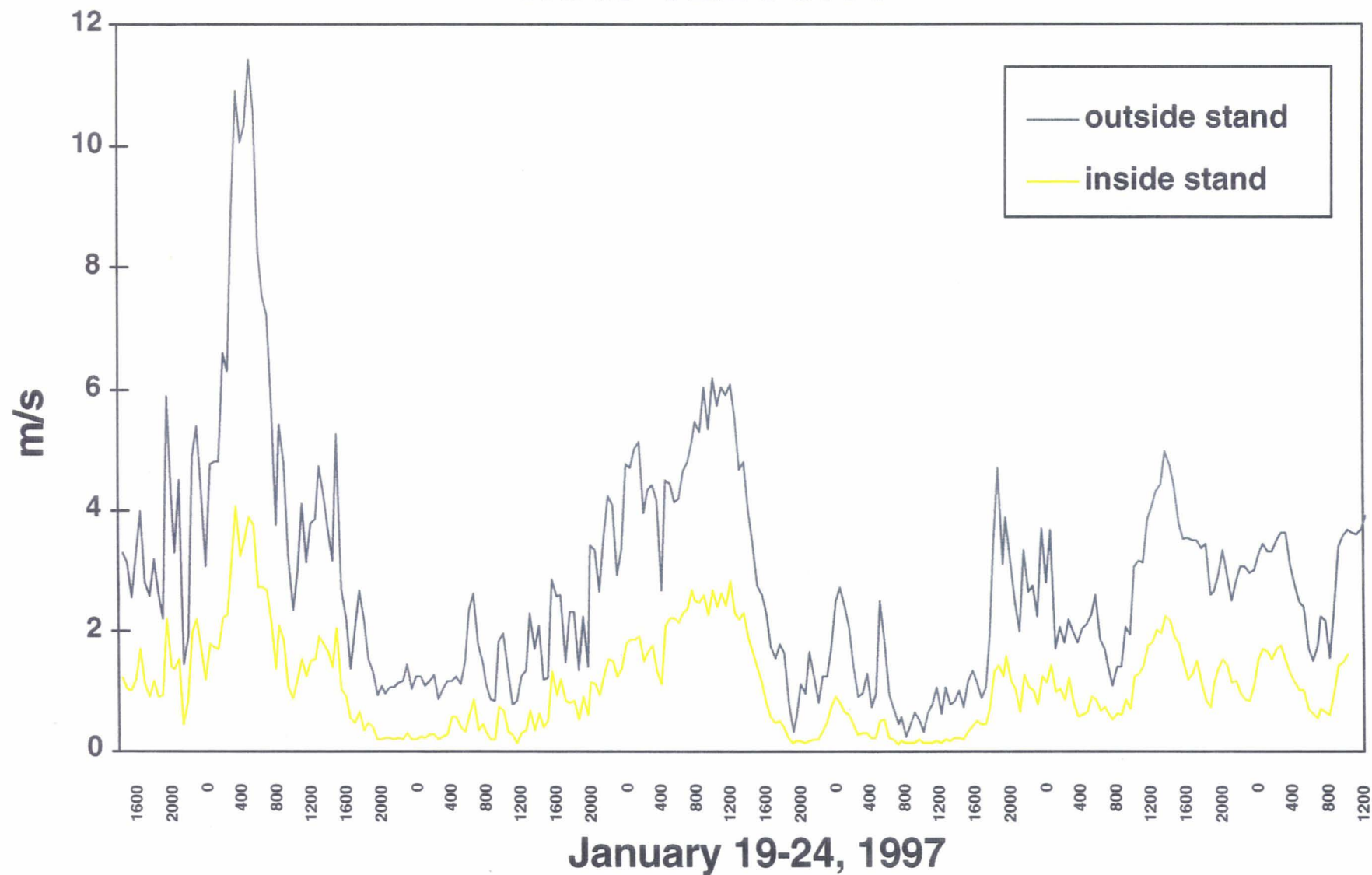


Figure 13. Amelioration of wind speed by a high density limber pine stand, Theodore Roosevelt Memorial Ranch.

FACILITATION AND LIMBER PINE

In stressful environments, abiotic conditions can severely limit plant species distribution and abundance (Huston 1979, Osmond et al. 1987). Amelioration of abiotic extremes by stress-tolerant plants can provide favorable microsites for less-tolerant flora and fauna (Callaway 1995). Because of these botanically derived microsites, ranges of species distribution may expand beyond what is normally physiologically possible, thereby creating patterns of distribution and abundance dependent on facilitation by neighboring plants (Vetaas 1992, Hacker and Bertness 1995, Callaway 1997). This process may occur under a variety of stressful, limiting abiotic conditions including temperature and water in deserts (Muller 1953, Muller and Muller 1956, Steenberg and Lowe 1969, Nobel 1984, Everett et al. 1986) and alpine environments (Carlsson and Callaghan 1991, Blundon et al. 1993), nutrients during primary succession (Connell and Slayter 1977, Walker and III 1986, Wood and Moral 1987, Blundon et al. 1993), salinity in salt marshes (Bertness 1991, Bertness and Shumway 1993, Fong et al. 1996), and soil oxygen in wetlands (Schat and Beckhoven 1991, Bertness and Shumway 1993). In harsh environments where wind, water, and light are limiting, trees are effective ameliorators, in part due to their sheer volume and mass (Walker et al. 1993, Jones et al. 1994).

The indirect influence of individual trees on undergrowth species has been well-studied in tropical and sub-tropical savanna systems, where temperature and water are limiting (Tupas and Sajise 1977, Walker et al. 1981, Belsky et al. 1989, Weltzin and Coughenour 1990, Vetaas 1992, Belsky 1994, Belsky and Canham 1994, Hochberg et al. 1994, Archer 1995, Barnes and Archer 1996), but not in temperate systems, particularly those at higher latitudes. In northcentral Montana on the Rocky Mountain Front, current dynamics in a temperate savanna provide an excellent opportunity to study abiotic amelioration by trees and the implications for associated undergrowth and late-successional species. There, abiotic conditions are extreme; wind, water, nutrients, and rapid temperature changes limit species distribution and abundance. In this savanna, limber pine is the dominant tree species. Once restricted by frequent fires to rocky, windswept ridges and riparian zones, limber pine is now more widespread on dry slopes of the fescue-dominated foothills. Currently, limber pine comprises 15-20% of the land cover (Ayers Baumeister *unpubl. data*, Redmond and Prather 1996). This conifer species is effective at ameliorating harsh abiotic conditions, including wind, snow, and light (Ayers Baumeister and Dean 1997) and may be facilitating a number of understory species.

Strong positive spatial patterns among species suggest limber pine might create microclimates suitable for the establishment and growth of understory species by providing shade, improving water relations, protecting from wind, and/or enhancing soil nutrients. I review these environmental factors and others below (Figure 15).

INFLUENCE OF TREES ON UNDERSTORY PLANTS

Light: Trees create shade for understory plants. In savannas, trees and shrubs can reduce the mean sub-canopy solar radiation by as much as 45-60% (Tiedemann and Klemmedson 1977, Belsky et al. 1989). Shade reduces both soil and plant temperatures and evapotranspiration in below-crown environments (Smith et al. 1987, Vetaas 1992,

Belsky 1994). For shade-adapted species, summer shade may be essential in minimizing water loss in the xeric environs of the Front. Shade may also be important in winter when environmental conditions include high irradiation levels, increased reflectance off snow, and cold temperatures—ideal conditions for inducing photoinhibition in some plants (Öquist 1983, Powles et al. 1983). For young seedlings establishing on the Front, chronic, possibly fatal, photoinhibition (Osmond 1994) might occur. The benefits of shade from limber pine may therefore be twofold: in summer, by reducing evapotranspiration and in winter, by preventing photoinhibition through reduction of PAR and insulation from cold temperatures (Ball 1994).

Wind: It has been well established that wind can have adverse effects on growth and physiological activities of plants (Grace 1977, Nobel 1981, van Gardingen and Grace 1991, Ennos 1997). Negative alterations of physiological processes by wind are primarily through physical reduction of the boundary layer. This causes both increased transpiration rates yielding greater water loss and decreased temperatures resulting in slower metabolic rates (Öquist 1983, van Gardingen and Grace 1991). Additionally, abrasion from windblown soil particles and ice can reduce cuticular wax and increase loss of plant water (Hadley and Smith 1986, van Gardingen and Grace 1991). In environments where wind is the limiting factor to growth and survival, plant species that do not adapt to the wind through mechanisms such as leaf area reduction, thickened cuticle, or stronger root base must avoid wind by sheltering beneath or behind other plants or topographic structures (Osmond et al. 1987). In the high steppe of Patagonia, where winds are strong, dry, and blow predominantly from one direction all year, Aguiar et al. (1992) noted that average wind velocity was 80% lower on the lee side of shrubs and evaporation rates were less than half of those for plants on the windward side. On the Front, wind is probably the most extreme of all abiotic conditions. Wind most likely influences the distribution and abundance of many species, and amelioration of wind by limber pine might lead to expansion of the normal physiological distribution of some species.

Water: Water availability is an essential component in the life history of most plants and strongly influences plant distribution. Water availability is directly tied to seedling survival (Livingston and Black 1987, Smit and van den Driessche 1992) and establishment (Osmond et al. 1987). Water availability as soil moisture provides the bulk of the water for most plants. Soil moisture is determined by local precipitation, aspect, and elevation; microsite gradients of moisture are dependent on snow accumulation and melting, evapotranspiration rates, soil texture, and temperature (Belsky et al. 1989, Vetaas 1992). On the Front, limber pine most likely influences water availability and soil moisture indirectly through reducing evapotranspiration via shade and wind amelioration and through snow accumulation.

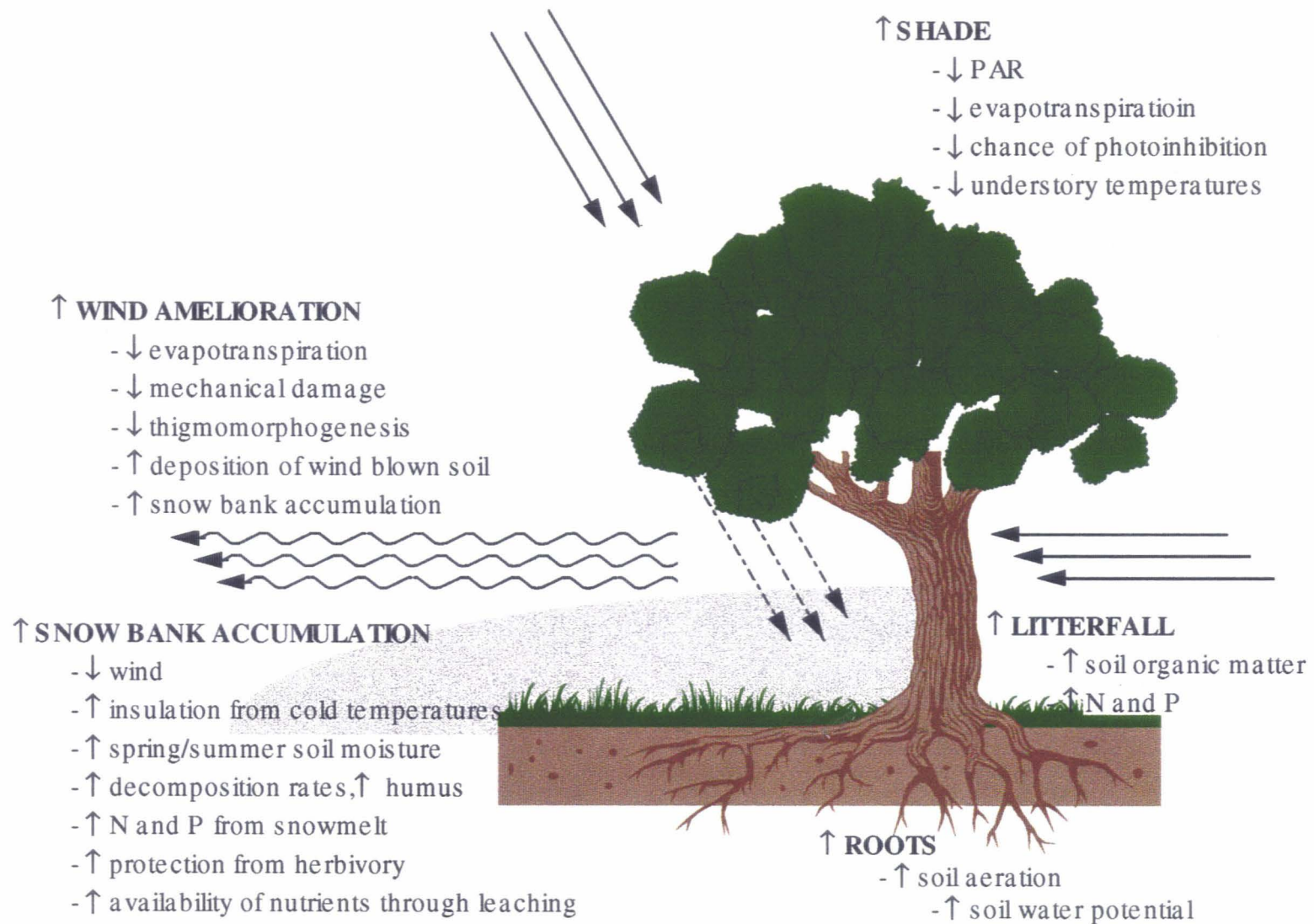
Snow Accumulation: Snow accumulates in drifts on the leeward side of physical obstructions, including topographic anomalies, rocks, and trees, as a result of the fluid dynamics of wind. The pattern of snowdrifts is structured by the stature of nearby vegetation, local topography, and melting and sublimation rates (Billings and Bliss 1959, West and Caldwell 1983). The positive effects of snow cover on plants are many: (1) the maintenance of higher soil temperatures during winter (+1 to -3°C), (2) lessening the impact of wind during winter, (3) provision of melt water, (4) protection against winter grazing by certain animals, (5) accumulation of blown soil, (6) increased availability of

nutrients from leaching, and (7) higher annual decomposition rates of soils (Billings and Bliss 1959, Holway and Ward 1963, Bleak 1970, Canaday and Fonda 1974, Weaver 1974, Schwab et al. 1987, Taylor and Jones 1990, Walker et al. 1993, among others).

On the Front, snow that falls is seldom around in spring to supplement soil moisture, due to the evaporative effects of the high, constant winds. Snow only supplements spring soil moisture through melting of wind-compacted snowdrifts in open areas and heavy snow cover in dense stands. Snowdrifts may also provide protection from wind for plants. In alpine areas (Evans and Fonda 1990) and in forested areas (Billings and Bliss 1959), the accumulation of snow both within stands and on the leeward side of individual trees can alter the micro-environment to the extent that snow cover, rather than just temperature or wind acting alone, can be the strongest influence in plant community patterns.

Nutrients: Trees in exposed sites can also influence pedoecological conditions. Improved fertility and structure of soils below tree crowns is common; soils beneath tree crowns often have significantly higher concentrations of organic matter, N, Ca, K, and P, higher microbial biomass, reduced bulk density, and increased water infiltration than open-grassland soils, all related to greater heterogeneity in litter and faster decomposition rates (reviewed in Vetaas 1992). Holtmeier and Broll (1992) found that in sub-alpine zones on the windward sides of tree islands, bare mineral soil is exposed by wind erosion and very little litter accumulates. In contrast, within islands and on the leeward side, thick humus layers and lush herbaceous vegetation enrich soil high organic matter and nutrient content. On the Front, total A and O horizon depth increases as limber pines age and is significantly greater beneath trees than in the open (Ayers Baumeister, *unpubl. data*). This increased organic content of the soil may be indirectly influencing the distribution of nutrient limited species.

INFLUENCE OF INCREASED CANOPY COVER ON ABIOTIC CONDITIONS



LIMBER PINE FACILITATION OF DOUGLAS FIR AND WAX CURRANT

Two species of particular interest for limber pine facilitation are Douglas-fir (*Pseudotsuga menziesii*) (Table 3) and wax currant (*Ribes cereum*) (Table 4). Douglas-fir is a mesic, seral conifer that shares 'climax' status with limber pine on the Front (Pfister and Hay 1988) and most likely represents successional changes from fescue grassland to more mesic limber pine/Douglas-fir communities.

Table 3. Douglas-fir (n=219) observed in 24, 0.045 ha (455 m²) plots on the Rocky Mountain Front, Montana. $\chi^2=66.9$, df=1, p<0.0001.

Cover type	Availability (rel. freq.)	Number of associated Douglas-fir	
		Observed	Expected
Open	0.62	77	136
Limber Pine	0.38	142 ¹	83

¹ fir located < 1m from trunk

Wax currant is a xeric, deciduous shrub that is an intermediate host for white pine blister rust (*Cronartium ribicola*). This introduced, often fatal, fungus persists in the inner bark of 5-needled pine species including western white pine (*Pinus monticola*), whitebark pine (*P. albicaulis*), sugar pine (*P. lambertiana*), and limber pine and completes half of its life cycle on the leaves of plants of the *Ribes* genus, the alternate host (Hoff 1992). Of 513 currant plants examined in summer 1997, 38% showed obvious signs of pine blister rust infection.

Table 4. Individual wax currants (n=513) observed in 33, 0.045 ha (455 m²) plots on the Rocky Mountain Front, Montana. $\chi^2=838$, df=2, p<<0.0001.

Cover type	Availability (rel. freq.)	Number of associated wax currant individuals	
		Observed	Expected
Open	0.63	43	323
Limber Pine (live)	0.25	404 ¹	128
Limber Pine (dead)	0.12	66 ¹	62

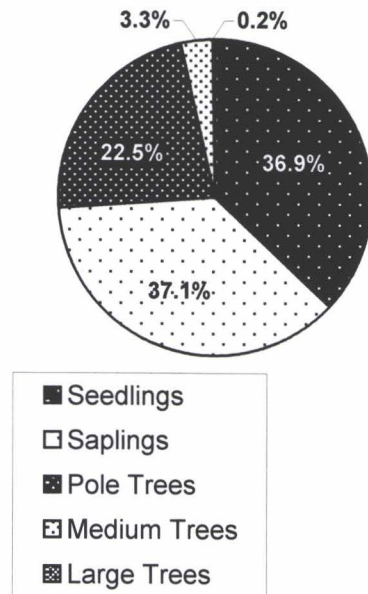
¹ currant located beneath canopy

BLISTER RUST IN LIMBER PINE

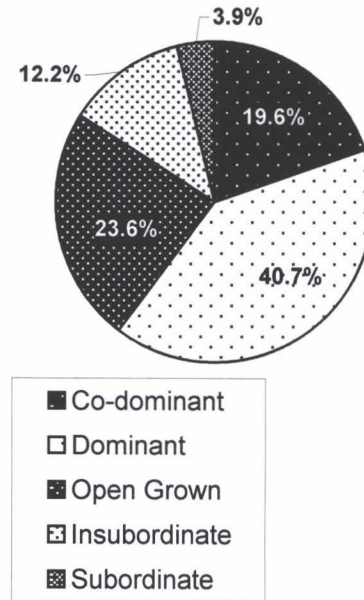
White pine blister rust is a disease of five-needled pines, including limber pine. The fungus infects trees through the needles, grows into the stem and forms fusiform cankers. This disease is native to Eurasia and arrived in North America in 1910 near Vancouver, British Columbia. Since its arrival, the fungus has taken a great toll on many five-needled pines, particularly western white pine and whitebark pine. Although a great deal of information has been reported on whitebark and western white pine and blister rust, little is known about its effects on limber pine, and in particular low-elevation populations of the Rocky Mountain Front.

In a survey of 81 limber pine stands throughout the northern Rockies, Kendall et al. (1996) found that over a third of limber pine trees were dead and about 75% of the remaining live trees are infected with rust. However, on the Front, only 21% of the trees were dead, with only a 30% infection rate. Unfortunately, the sample size was very limited. In 1997, I undertook a broader survey of limber pine along the Rocky Mountain Front, sampling 42 stands as per the same protocol as Kendall et al. (1996). Infection rates for limber pine in this study area appear to be higher. Of 2500 trees examined along the southern portion of the Front, pine blister rust was found in 46% of live limber pine trees (Ayers Baumeister, *unpubl. data*). Characteristics of individual trees and infection rates are presented in Figures 16 and 17. A comprehensive table describing stand characteristics and infection rates is found in Table 5.

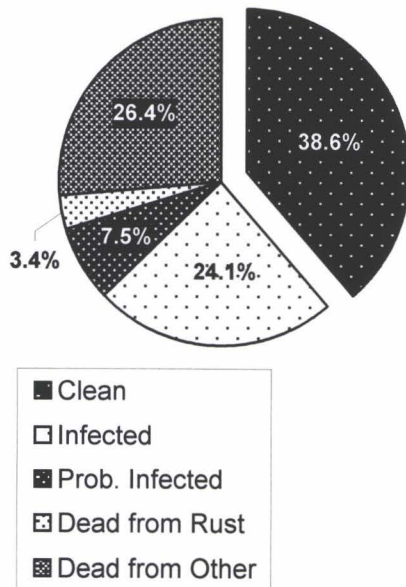
Distribution of Size Classes



Distribution of Canopy Status of Individuals



Distribution of Rust Infection



Distribution of Condition Classes

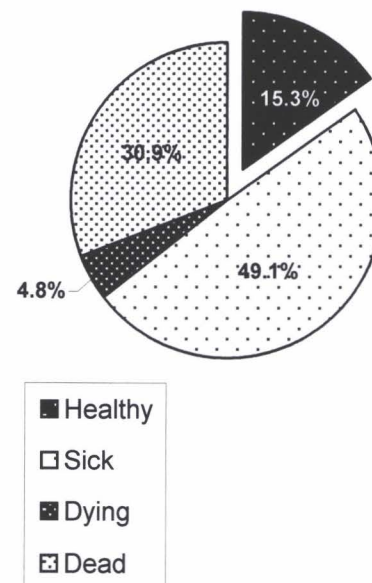


Table 5. Infection Rates and Community Characteristics. Dominants for each canopy layer (upper > 2m, middle 1-2 m and lower <1m in height) are species 6 letter codes. Infection rates are based on a minimum of 50 trees along a transect through each stand. Infection rates do not appear to be correlated with any stand characteristics measured.

Plot #	Upper Layer Dominants		Middle Layer Dominants		Lower Layer Dominants		Elev. (ft.)	Aspect	Slope (%)	Density Indiv./m2	Infection Rate (%)
	Spp. 1	Spp. 2	Spp. 1	Spp. 2	Spp. 1	Spp. 2					
1	PINFLE	NP	PINFLE	NP	JUNHOR	POTFRU	4740	196	1	0.36	75.3%
2	PINFLE	NP	PINFLE	NP	POTFRU	ARCUVA	4850	132	1	0.25	39.7%
3	PINFLE	NP	SHECAN	POTFRU	ROSWOO	SYMALB	5040	62	20	1.20	36.1%
4	PINFLE	NP	RIBVIS	NP	FESSCA	POTFRU	5100	274	22	0.33	55.9%
5	PINFLE	NP	AMEALN	SHECAN	AMEALN	FESSCA	4800	53	14	0.23	52.4%
6	PINFLE	NP	SHECAN	NP	ELYTRA	JUNHOR	4800	140	4	0.36	36.9%
7	PINFLE	PSEMEN	PSEMEN	NP	JUNHOR	ARCUVA	4563	235	3	0.14	33.9%
8	PINFLE	NP	NP	NP	ARCUVA	JUNHOR	5140	292	22	0.13	22.8%
9	PINFLE	BET SPP2	SHECAN	NP	JUNCOM	ARCUVA	5200	260	15	0.08	29.4%
10	PINFLE	NP	POPTRE	NP	JUN SPP	ARCUVA	5420	43	32	0.36	27.7%
11	PINFLE	NP	NP	NP	SHECAN	ARCUVA	5500	321	25	0.31	48.1%
12	PINFLE	NP	SHECAN	NP	FORBS	POTFRU	4989	274	14	0.14	36.5%
13	PINFLE	NP	SHECAN	NP	JUNHOR	POTFRU	5000	103	17	0.42	47.4%
14	PINFLE	NP	NP	NP	FESSCA	JUNHOR	4888	294	35	0.11	12.0%
15	PINFLE	NP	NP	NP	FESSCA	NP	5450	318	37	0.04	23.8%
16	PINFLE	NP	NP	NP	GRASS	SIMALB	5385	238	45	0.14	18.9%
17	PINFLE	PSEMEN	PHLPAL	NP	GRASS	FORB	4482	348	60	0.07	11.3%
18	PINFLE	NP	RIBVIS	NP	ELYTRA	JUNHOR	4420	292	22	0.12	16.9%
19	PINFLE	PSEMEN	RIBVIS	NP	FESSCA	FORB	4303	312	12	0.07	4.8%
20	PINFLE	PSEMEN	POTFRU	SHRUB	FESSCA	SIMALB	4973	290	35	0.21	17.2%
21	PINFLE	SALSCO	ROSWOO	PRUVIR	BALSAG	SYMALB	5252	100	34	0.11	14.0%
22	PINFLE	NP	NP	NP	FESSCA	BALSAG	5330	69	43	0.11	25.4%
23	PINFLE	NP	PINFLE	NP	FESSCA	JUNHOR	4852	317	30	0.20	10.9%
24	PINFLE	NP	PINFLE	NP	FESSCA	JUNHOR	4534	180	22	0.09	16.4%
25	PINFLE	NP	NP	NP	FESSCA	JUNHOR	4521	126	12	0.11	44.2%
26	PINFLE	NP	NP	NP	JUNHOR	FESSCA	4498	244	40	0.14	30.0%
27	PINFLE	NP	RIBVIS	NP	FESSCA	LITHOS	4498	37	5	0.10	58.3%
28	PINFLE	PSEMEN	RIBVIS	SHRUB	FESSCA	JUNHOR	4570	253	17	0.06	56.9%
29	PINFLE	NP	FESSCA	POTFRU	JUNHOR	GRASS	4209	191	10	0.08	33.3%
30	PINFLE	NP	NP	NP	JUNHOR	FESSCA	4895	158	13	0.16	43.1%
31	PINFLE	NP	PINFLE	NP	FESSCA	JUNHOR	4830	348	7	0.06	28.3%
32	PINFLE	PSEMEN	SHRUB	NP	FESIDA	JUNHOR	4830	320	2	0.09	34.0%
33	PINFLE	PSEMEN	RIBVIS	NP	FESSCA	MOSS	4657	120	2	0.09	23.5%
34	PINFLE	NP	PINFLE	NP	FESSCA	JUNHOR	4898	130	1	0.11	17.5%
35	PINFLE	NP	PINFLE	SHECAN	JUNHOR	FORBS	4891	69	7	0.60	22.2%
36	PINFLE	NP	POTFRU	NP	JUNHOR	POTFRU	4488	NA	0	0.09	22.0%
37	PINFLE	NP	PINFLE	NP	JUNHOR	ARCUVA	4836	55	38	0.06	71.7%
38	PINFLE	PSEMEN	POTFRU	PINFLE	JUNHOR	FESSCA	5405	35	41	0.17	48.2%
39	PINFLE	PSEMEN	PINFLE	PSEMEN	FESSCA	JUNHOR	5181	11	45	0.28	60.0%
40	PINFLE	NP	NP	NP	FESSCA	FESIDA	4615	248	37	0.21	53.7%
41	PINFLE	PINPON	NP	NP	FESSCA	NP	4612	272	46	0.04	50.0%
42	PINFLE	NP	NP	NP	GRASSES	FORBS	0	222	33	0.28	50.0%

WILDLIFE AND LIMBER PINE

Limber pine is suspected to be of high value for wildlife, both as shelter in harsh environments and as a food resource (Steele 1990). The seeds are a nutritious source of food consumed by birds (Lanner 1996), rodents (Benkman et al. 1984) and bears (Kendall 1996 pers. commun., McCutchen 1996). Bird species that frequent limber pine include blue grouse (*Dendragapus obscurus*) (Pekins et al. 1989), Dusky flycatcher (*Empidonax oberholseri*) (Kelly 1993) and Clark's Nutcracker (*Nucifraga columbiana*) (Lanner and van der Wall 1980). The nutcracker, the only known dispersal agent of limber pine, caches its large seeds in areas commonly free of snow in winter (Benkman et al. 1984, Lanner 1996). Unrecovered caches germinate and grow in clumps due to multiple seeds within a cache (Linhart and Tomback 1985, Carsey and Tomback 1994). Porcupine (*Erethizon dorsatum*) have been observed feeding on the bark in southwestern Alberta (Harder 1980). Also commonly observed in limber pine along the Front are mule deer (*Odocoileus hemionus*), mountain lion (*Felis concolor*), Townsend's Solitaire (*Myadestes townsendii*), Western Tanager (*Piranga ludoviciana*), black-capped (*Parus atricapillus*) and mountain chickadee (*P. gambeli*), and Bohemian waxwing (*Bombycilla garrula*) (Baumeister *in prep.*).

Table 6. Bird Species by Habitat. GRASS includes all fescue grasslands (*Festuca scabrella* and *F. idahoensis*) including areas with significant cover of *Potentilla fructosa*. RIPRN is all riparian areas where the recording was associated with riparian vegetation and not the water. ASPEN is all *Populus tremuloides* stands with at least 50% canopy cover of aspen. OLIMB, open *Pinus flexilis* habitats are those with less than 50% canopy cover. DLIMB, dense *Pinus flexilis* habitats are those with >50% canopy cover, often a *Pseudotsuga menziesii* component. WATER as habitat was recorded when the sighting was actually in the water. AGRIC, agriculture refers to all alfalfa, wheat, and hay fields. DOMST, domestic habitats are those that are associated with human buildings, including all ranching constructions, with the exception of fences. Bolded species are those that were found at least once in limber pine. Italicized species are those that were found in limber pine disproportionately more than that habitat was available. Sampling occurred over a 3-year period and all habitats were sampled proportional to availability. (Baumeister and Baumeister unpubl. data).

Common Name		Season	GRASS	RIPRN	ASPEN	OLIMB	DLIMB	WATER	AGRIC	DOMST	TOTAL
American Avocet	native	summer	0	0	0	0	0	13	0	0	13
American Coot	native	summer	0	0	0	0	0	5	0	0	5
<i>American Crow</i>	<i>native</i>	<i>yearlong</i>	76	7	3	43	35	0	23	0	187
<i>American Goldfinch</i>	<i>native</i>	<i>summer</i>	30	44	0	51	30	0	0	0	155
American Kestrel	native	summer	26	1	1	16	0	0	2	0	46
American Redstart	native	summer	0	2	5	2	0	0	0	0	9
<i>American Robin</i>	<i>native</i>	<i>summer</i>	31	66	24	61	30	0	11	0	223
American Tree Sparrow	native	yearlong	0	8	0	15	0	0	0	0	23
American White Pelican	native	summer	7	16	0	0	0	2	0	0	25
American Wigeon	native	summer	3	3	0	0	0	37	2	0	45
Bank Swallow	native	summer	0	2	0	0	0	16	3	0	21
Barn Swallow	native	summer	3	5	0	0	0	16	1	3	28
Barrow's Goldeneye	native	summer	0	0	0	0	0	5	0	0	5
<i>Belted Kingfisher</i>	<i>native</i>	<i>yearlong</i>	0	8	0	1	0	0	0	0	9
<i>Black-billed Magpie</i>	<i>native</i>	<i>yearlong</i>	50	6	7	21	10	0	6	7	107
<i>Black-capped Chickadee</i>	<i>native</i>	<i>yearlong</i>	1	6	2	24	30	0	0	0	63
Black-headed Grosbeak	native	summer	0	1	0	0	0	0	0	0	1
<i>Blue Grouse</i>	<i>native</i>	<i>yearlong</i>	6	2	0	65	10	0	0	0	83
Blue-winged Teal	native	summer	0	0	0	0	0	6	0	0	6
Bobolink	native	summer	0	0	0	0	0	0	5	0	5
<i>Brewer's Blackbird</i>	<i>native</i>	<i>summer</i>	338	147	0	33	10	0	26	0	554
Brown Trasher	native	summer	1	1	0	0	0	0	0	0	2
Brown-headed Cowbird	native	summer	2	30	0	0	0	0	0	0	32
California Gull	native	summer	30	3	0	0	0	78	201	4	316
Canada Goose	native	yearlong	47	16	0	0	0	81	52	0	196
Canvasback	native	summer	0	0	0	0	0	5	0	0	5
Cassin's Finch	native	yearlong	0	0	1	0	0	0	0	1	2
<i>Cedar Waxwing</i>	<i>native</i>	<i>summer</i>	0	19	0	0	8	0	0	0	27
<i>Chipping Sparrow</i>	<i>native</i>	<i>summer</i>	94	16	1	256	50	0	0	0	417
Cinnamon Teal	native	summer	0	0	0	0	0	15	0	0	15
<i>Clark's Nutcracker</i>	<i>native</i>	<i>yearlong</i>	3	0	0	52	9	0	0	0	64
<i>Clay-colored Sparrow</i>	<i>native</i>	<i>summer</i>	92	23	3	6	0	0	0	0	124
Cliff Swallow	native	summer	2	10	0	0	0	0	0	0	12
Common Goldeneye	native	summer	0	0	0	0	0	5	0	0	5
Common Grackle	native	summer	0	0	0	1	0	0	0	0	1
Common Merganser	native	summer	0	4	0	0	0	13	0	0	17
Common Nighthawk	native	summer	0	1	1	0	0	0	0	0	2
<i>Common Raven</i>	<i>native</i>	<i>yearlong</i>	37	0	4	17	31	1	3	0	93
<i>Common Snipe</i>	<i>native</i>	<i>summer</i>	54	45	1	3	0	2	7	0	112
Common Yellowthroat	native	summer	1	34	0	0	0	0	0	0	35
Cooper's Hawk	native	summer	2	0	0	0	0	0	0	0	2
Cordilleran Flycatcher	native	summer	0	2	0	0	0	0	0	0	2
<i>Dark-eyed Junco</i>	<i>native</i>	<i>yearlong</i>	0	28	5	38	31	0	20	0	122

Common Name		Season	GRASS	RIPRN	ASPEN	OLIMB	DLIMB	WATER	AGRIC	DOMST	TOTAL
Double-crested Cormorant	native	summer	0	0	0	0	0	20	0	0	20
Downy Woodpecker	native	yearlong	0	6	2	1	0	0	0	0	9
Dusky Flycatcher	native	summer	0	20	1	15	30	0	0	0	66
Eastern Kingbird	native	summer	29	18	2	1	0	0	0	0	50
European Starling	introduced	yearlong	3	68	1	0	0	0	31	2	105
Fox Sparrow	native	summer	0	5	0	0	0	0	0	0	5
Gadwall	native	summer	0	0	0	0	0	21	0	0	21
Golden Eagle	native	yearlong	14	1	0	8	2	0	0	0	25
Golden-crowned Kinglet	native	yearlong	0	0	0	1	0	0	0	0	1
Gray Catbird	native	summer	0	4	0	0	0	0	0	0	4
Gray Partridge	introduced	yearlong	2	0	0	0	0	0	0	0	2
Great Blue Heron	native	summer	4	6	0	0	0	0	0	0	10
Green-winged Teal	native	summer	0	0	0	0	0	1	0	0	1
<i>Hairy Woodpecker</i>	native	yearlong	0	12	5	1	0	0	1	0	19
Hooded Merganser	native	summer	0	0	0	0	0	2	0	0	2
Horned Grebe	native	summer	0	0	0	0	0	4	0	0	4
Horned Lark	native	yearlong	12	0	0	0	0	0	6	0	18
House Sparrow	introduced	yearlong	1	0	0	0	0	0	0	2	3
<i>House Wren</i>	native	summer	2	10	15	1	0	0	0	0	28
Killdeer	native	summer	62	0	0	0	0	2	4	0	68
Lark Bunting	native	summer	70	0	0	0	0	0	5	0	75
Lark Sparrow	native	summer	14	0	0	0	0	0	0	0	14
Least Flycatcher	native	summer	0	2	0	0	0	0	0	0	2
Lesser Scaup	native	summer	0	0	0	0	0	26	0	0	26
Long-billed Curlew	native	yearlong	85	1	1	0	0	0	12	0	99
MacGillivray's Warbler	native	summer	0	0	0	1	5	0	0	0	6
Mallard	native	yearlong	19	12	0	0	0	119	0	0	150
Marbled Godwit	native	summer	37	0	0	0	0	7	5	0	49
Merlin	native	summer	8	1	0	9	0	0	1	0	19
Mountain Bluebird	native	summer	17	12	7	15	1	0	1	0	53
Mountain Chickadee	native	yearlong	1	6	1	40	24	0	0	0	72
<i>Mourning Dove</i>	native	summer	17	22	0	7	0	0	27	0	73
Nashville Warbler	native	summer	0	0	0	0	1	0	0	0	1
Northern Flicker	native	yearlong	5	31	9	30	21	0	0	0	96
<i>Northern Harrier</i>	native	summer	53	6	0	8	0	0	9	0	76
Northern Oriole	native	summer	0	2	0	0	0	0	0	0	2
Northern Pintail	native	summer	0	0	0	0	0	5	2	0	7
Northern Rough-winged Swallow	native	summer	0	13	0	0	0	0	9	0	22
Northern Shoveler	native	summer	0	0	0	0	0	18	0	0	18
Northern Waterthrush	native	summer	0	1	0	0	0	0	0	0	1
Olive-sided Flycatcher	native	summer	1	0	0	0	0	0	0	0	1
Orange-crowned Warbler	native	summer	0	5	0	0	0	0	0	0	5
Osprey	native	summer	1	0	0	0	0	0	0	0	1
Pine Siskin	native	yearlong	1	15	0	0	15	0	0	0	31
Prairie Falcon	native	summer	0	0	0	1	0	0	0	0	1
Red Crossbill	native	yearlong	0	0	0	0	15	0	0	0	15
Red-breasted Nuthatch	native	yearlong	0	0	0	10	20	0	0	0	30
Red-eyed Vireo	native	summer	0	2	1	2	0	0	0	0	5
Red-naped Sapsucker	native	summer	0	10	0	0	0	0	0	0	10
Red-necked Grebe	native	summer	0	0	0	0	0	2	0	0	2
<i>Red-tailed Hawk</i>	native	yearlong	13	17	0	5	0	0	3	0	38
Red-winged Blackbird	native	summer	23	65	0	0	0	15	2	0	105
Ring-necked Duck	native	summer	0	0	0	0	0	9	0	0	9
<i>Ring-necked Pheasant</i>	introduced	yearlong	11	2	0	2	0	0	4	0	19
Rock Dove	introduced	yearlong	14	0	0	0	0	0	0	3	17
Ruby-crowned Kinglet	native	summer	10	13	0	7	20	0	0	0	50

Common Name		Season	GRASS	RIPRN	ASPEN	OLIMB	DLIMB	WATER	AGRIC	DOMST	TOTAL
Ruffed Grouse	native	yearlong	3	15	5	4	2	0	0	0	29
Rufous-sided Towhee	native	summer	0	4	0	0	0	0	0	0	4
Sandhill Crane	native	summer	6	8	0	0	0	0	5	0	19
Savannah Sparrow	native	yearlong	165	15	0	0	0	0	15	0	195
Say's Phoebe	native	summer	0	0	0	1	0	0	0	0	1
Sharp-shinned Hawk	native	summer	1	0	0	0	0	0	0	0	1
Sharp-tailed Grouse	native	yearlong	51	11	0	11	3	0	9	0	85
Solitary Vireo	native	summer	0	0	0	0	5	0	0	0	5
<i>Song Sparrow</i>	<i>native</i>	<i>summer</i>	<i>46</i>	<i>40</i>	<i>0</i>	<i>3</i>	<i>0</i>	<i>0</i>	<i>1</i>	<i>0</i>	<i>90</i>
Spotted Sandpiper	native	summer	0	11	0	0	0	13	0	0	24
Sprague's Pipit	native	summer	6	0	0	0	0	0	0	0	6
Swainson's Hawk	native	summer	10	3	0	4	0	0	2	0	19
Swainson's Thrush	native	summer	0	6	0	1	5	0	0	0	12
<i>Townsend's Solitaire</i>	<i>native</i>	<i>yearlong</i>	<i>2</i>	<i>0</i>	<i>0</i>	<i>21</i>	<i>5</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>28</i>
Tree Swallow	native	summer	2	59	0	0	0	14	1	1	77
Upland Sandpiper	native	summer	10	0	0	0	0	0	0	0	10
<i>Veery</i>	<i>native</i>	<i>summer</i>	<i>0</i>	<i>6</i>	<i>0</i>	<i>1</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>7</i>
Vesper Sparrow	native	summer	76	3	0	18	0	0	0	0	97
Violet-green Swallow	native	summer	0	4	0	0	0	0	0	0	4
Warbling Vireo	native	summer	0	0	15	0	15	0	0	0	30
Western Bluebird	native	summer	1	0	0	2	0	0	0	0	3
Western Kingbird	native	summer	3	0	0	0	0	0	0	0	3
<i>Western Meadowlark</i>	<i>native</i>	<i>summer</i>	<i>195</i>	<i>2</i>	<i>0</i>	<i>2</i>	<i>0</i>	<i>0</i>	<i>5</i>	<i>0</i>	<i>204</i>
Western Tanager	native	summer	1	0	0	0	5	0	0	0	6
Western Wood-pewee	native	summer	4	1	5	0	5	0	0	0	15
<i>White-crowned Sparrow</i>	<i>native</i>	<i>summer</i>	<i>22</i>	<i>51</i>	<i>4</i>	<i>27</i>	<i>22</i>	<i>0</i>	<i>26</i>	<i>2</i>	<i>164</i>
Willet	native	summer	3	0	0	0	0	2	0	0	5
Willow Flycatcher	native	summer	0	15	0	0	0	0	0	0	15
Wilson's Phalarope	native	summer	0	0	0	0	0	48	0	0	48
Wilson's Warbler	native	summer	0	2	0	0	0	0	0	0	2
<i>Yellow Warbler</i>	<i>native</i>	<i>summer</i>	<i>0</i>	<i>34</i>	<i>2</i>	<i>1</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>37</i>
Yellow-headed Blackbird	native	summer	8	0	0	0	0	0	0	0	8
Yellow-rumped Warbler	native	summer	7	40	3	59	20	0	0	0	129

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